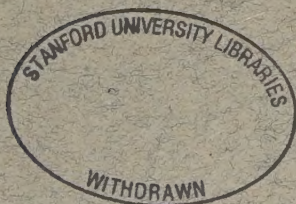




AN AGRICULTURAL SURVEY OF NEBRASKA

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AN AGRICULTURAL SURVEY OF NEBRASKA.*

BY JOSEPH ALLEN WARREN, PH.D.

INTRODUCTION.

In 1854 there was not over one square mile of land under cultivation in the territory of Nebraska,† but the unsurpassed fertility of the soil and the salubriousness of the climate had begun to attract attention. Many a miner who crossed her rolling prairies seeking gold in California, being disappointed in his quest for wealth, returned and took the surer course of gathering golden harvests from Nebraska's wealth of soil. Many a soldier returning from the war accepted the government's invitation to make his home upon 160 acres of trans-Missouri land.

The advancing price of land in the East, and improvement in transportation and machinery, but most of all the remarkable responsiveness of the soil and the ease with which it could be cultivated, brought about a development which for rapidity and stability has rarely been equalled. Within the memory of comparatively young men still living in Nebraska, the state has been transformed from a great hunting ground to one of the most prosperous, most productive and best improved agricultural states in the Union. The men who slept in buffalo robes while they drove back the roving Indians have lived to see their home state now standing third in the production of corn, fourth in wheat and oats, fifth in rye, third in hogs, fourth in cattle, and sixth in horses and mules; to see her produce more than one-thirteenth the corn, one-fourteenth of the wheat, one-fifteenth of the oats, one-fourteenth of the hogs, and one-eigteenth of the cattle of the whole United States.

Not only is Nebraska one of the first half dozen states in agricultural production, but she is the most purely agricultural of them all. There is not a commercial forest or mine within her borders. And this is only the beginning. The past and present are only an index of the possibilities for the future. Not one acre in three has ever known the plow. Of the other two-thirds probably one-half is untillable. This leaves still many millions of acres of arable land untilled, and that that is cultivated is as yet doing scarcely more than half of what it is easily capable.

* It is impossible to mention the names of all the persons to whom thanks are due for assistance in assembling the material here presented, and for offering valuable suggestions. Especial acknowledgment is due, however, to Dr. G. E. Condra for reading the manuscript and for many valuable suggestions and much information, particularly on soils, geology, topography, etc.; to Prof. G. A. Loveland for reading the chapter on climate and for furnishing nearly all the data therein and the data from which the charts have been made; to Prof. Alvin Keyser, Mr. Adna Dobson, Dr. E. H. Barbour, and many others for suggestions and data. The crop and stock distribution charts have been made from data contained in the 1908 crop report of the Nebraska Bureau of Labor and Industrial Statistics.

† Hon. J. Sterling Morton in report of Secretary of Nebraska State Board of Agriculture, 1905.

In this reconnaissance nothing more can be attempted than to give a bird's eye view, as it were, of the agricultural geography, and point out some of the factors controlling production, with the hope that it will enable those interested to form a better idea of the State and also to encourage some residents to make better use of the opportunities at hand. For these reasons it has seemed necessary to devote considerable space to a review of the climate, geology, topography, etc., in order that their influence on agriculture may be shown and that persons unfamiliar with the state may more easily understand the conditions.

Climate and soil constitute the natural agricultural resources of any country. Geology and climate of the past have made the soil what it is. The present climate, the soil, and the topography, determine the agricultural possibilities. The physical condition of the soil is determined by its structure, its chemical composition, the weather and the tillage. These determine the crop producing power, but the best soil is useless without favorable climatic conditions.

There are always many factors which affect directly the distribution of crops, that is, influences which determine how well that crop thrives or the profit which it produces. Among the most important of these forces are soil, topography, rainfall, temperature, length of season, roads and markets. Which of these factors is most important we will not attempt to say. Favorable conditions with respect to all are absolutely essential. Very adverse conditions with respect to any one may, and often does, completely nullify the effect of favorable conditions with respect to all the others combined. Each of these forces becomes the limiting factor for the production of some crop in some part of the state. For example, an extremely poor soil, such as pure sand, is incapable of producing corn. Along the Missouri river and other streams are many tracts of rich soil on bluffs so steep as to make cultivation impossible. In many parts of the west conditions are favorable except moisture, without which nothing can be grown. Temperature excludes peaches from the northern part, and the length of the season there is not sufficient for Kafir. In the sand hills of northern Nebraska are valleys where large crops of potatoes could be grown, but the distance to market and the bad roads make disposition of the crop impossible, while in Keya Paha county distance to market alone limits this crop.

CLIMATE.

While we do not wish to make any extended discussion of the climate, yet an article of this nature would be incomplete without at least a sufficient summary of climatic conditions, so that readers unfamiliar with those conditions may not be inconvenienced to obtain reliable information of this sort.

The physiographic features of the state are such as to have little influence upon its climate. The climate is mainly determined by the position on the continent and not by anything within its borders except altitude. The altitude does affect the temperature, the evaporation and

perhaps the rainfall. The distance from the equator, the distance and direction from the Gulf of Mexico and the Rocky Mountains are the main factors in determining our climate.

Temperature.—The average annual temperature for the state as a whole for the past thirty-three years has varied from 45.7 to 51.3 degrees, with a mean of 48.5 degrees.

Table No. 1 shows the mean temperature and the highest and lowest temperatures recorded anywhere in the state for each year from 1876 to 1908. It should be remembered that the maximum and minimum temperatures here given did not occur all over the state, but are the highest and lowest temperatures, respectively, observed at any place in the entire state during the year.

TABLE NO. 1.—*Maximum, Minimum, and Average Temperature of Nebraska by Years.*

YEARS.	TEMPERATURE.			YEARS.	TEMPERATURE.		
	Mean.	Max.	Min.		Mean.	Max.	Min.
1876	47.6	103	—25	1894	50.0	114	—38
1877	48.5	107	—16	1895	48.6	110	—34
1878	49.4	103	—16	1896	49.4	109	—22
1879	48.6	100	—27	1897	49.1	113	—26
1880	47.4	105	—26	1898	48.5	109	—22
1881	48.0	104	—35	1899	47.8	108	—47
1882	49.2	106	—21	1900	51.3	110	—29
1883	45.7	109	—34	1901	50.1	111	—38
1884	46.5	101	—39	1902	48.6	111	—39
1885	47.4	100	—27	1903	48.1	103	—34
1886	47.6	110	—33	1904	49.0	105	—27
1887	47.5	106	—32	1905	48.0	104	—45
1888	47.3	105	—36	1906	49.0	104	—28
1889	49.3	111	—27	1907	48.8	112	—32
1890	49.3	112	—34	1908	50.3	107	—24
1891	47.7	110	—38	Average for			
1892	47.7	113	—42	33 years....	48.5	107	—31
1893	47.6	110	—28				

The temperature is by no means the same for all parts of the state, being 52 degrees in the southeast, 50 degrees in the southwest, 46 degrees along the north and 45 degrees in the northwest corner, as shown by chart No. 1.

There is a lack of data in the Sand Hill Region and in the western counties. In the extreme western counties, most of the observations have been made in valleys which are 200 to 1,000 feet below the general level of the country. In drawing the lines these facts have been taken into consideration, but no great accuracy can be claimed for the lines in the regions mentioned.

The temperature decreases with elevation and latitude. The elevation increases about 2,500 feet from east to west along the southern border, and there is a decrease in temperature of 2 degrees. From south to north the elevation in general increases and the latitude also increases,

both working together to produce lower temperatures in the north, and we find a decrease of about 1 degree to thirty-five miles, or from 52 degrees in the southeast to 46 degrees along the northern border. January is the coldest month in the year, with an average temperature of 21.1 degrees, but this does not mean that January is the coldest month every year, nor that the coldest days of every year occur in January for they may come in December, January, February, or even March. It means that for the past thirty-three years the average temperature of January has been lower than that of any other month.

All parts of the state may expect the temperatures of the coldest days to be from 18 to 20 degrees or more below zero every year. In a few rare instances temperatures 40 to 47 degrees below zero have been recorded in the northern counties. These low temperatures are seldom maintained for more than a few days. At such times there is usually little wind, the air is generally quite dry and the sky clear, and therefore the cold is not felt to any such extent as it would be in a more humid climate. February is a little warmer than January. From February on there is quite a gradual rise in temperature until July, the warmest month, is reached. August is slightly cooler and after that the decline in temperature is quite gradual. This is shown graphically in chart No. 2.

The maximum temperature for the season at any particular place is usually between 95 and 105 degrees, but higher temperatures have occasionally been recorded.

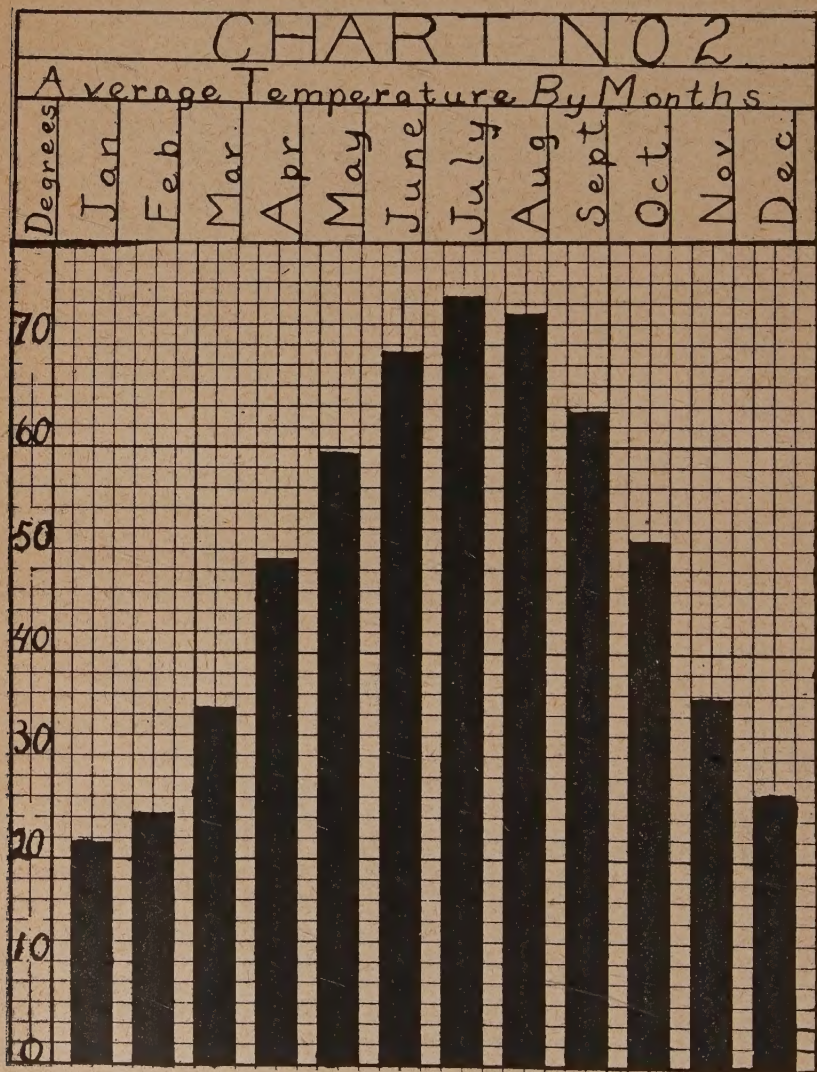
While July, on the average, is the warmest month, the warmest days may occur in June, July, August or September. These high temperatures seldom obtain for more than a few hours at a time, and then there is usually some breeze and the air is quite dry. In fact, such high temperatures seldom occur except during dry spells, so that they are not so oppressive as they would otherwise be, but the effect on vegetation is often severe. In the evening there is usually a considerable drop in temperature, so that even in the hottest weather the nights are nearly always comfortably cool.

THE ADVANCE OF THE SEASON.*

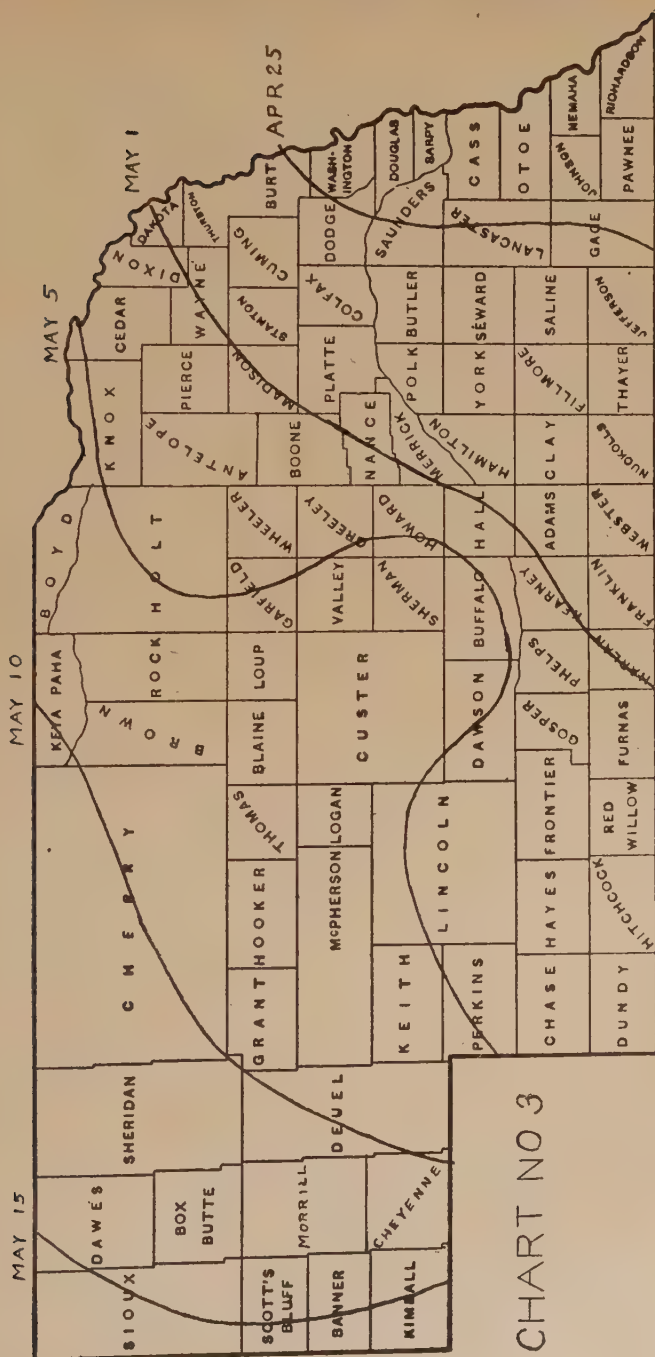
The ground usually thaws out so that spring work can begin before the middle of March in the southern counties and by the first of April in the northern counties. In exceptionally early seasons a little spring wheat has been sown in the southwest counties in February, while in a few rare years, practically no work on the farm had been done before April 1; usually during a quarter to a half of March the conditions are such that plowing and seeding progress nicely in southern Nebraska. This period is not necessarily the last days of March, for frequently seeding in March is interrupted by a cold, stormy period which, of course, may extend into April, but this, however, is less likely to occur.

* U. S. Climatic and Crop Service, Neb. Sec.; May to October, 1903.

The first two weeks in April is the time when the bulk of the spring wheat and oats is ordinarily sown, although oat sowing continues to a large extent for a week or ten days later, especially in the northern



counties. The average date for the fifteen years on which all spring wheat was sown is April 16, and for oats April 21. In a few of the earliest years, wheat seeding was completed in the first week in April and oat seeding the first part of the second week, while the most back-



AVERAGE DATE OF LAST KILLING FROST IN SPRING.

ward years wheat seeding continued into the last week in April, and oat seeding into the first week in May.

"About the time oat seeding is finished, early fruit begins to blossom, April 22 being the average date on which blossoms begin to be noticeable. The earliest of the fifteen years were 1895 and 1896, when the first blossoms began to open April 9 and 13 respectively. The most backward years were 1893 and 1892, the dates May 9 and 6, respectively." The date of full bloom is about ten days later than the date of beginning to bloom. The records concerning fruit are practically confined to the southeast section.

The foregoing map (chart No. 3) shows the average date in the spring when the last killing frost or freeze occurs. The very earliest date in which the last killing frost has occurred is about three weeks earlier and the latest about three weeks later than the average date.

In the southeastern counties corn planting usually begins soon after the middle of April, but does not become general till about May 1. The crop is nearly all in, in all except the northwest counties by May 25. In early seasons it may be completed as early as May 15, while in extremely late years much corn is planted the first week in June.

Cultivation begins soon after planting is completed, usually the first week in June in most counties. The earliest fields in the southeast counties are usually "laid by" in June and the bulk of the crop before June 15 in all counties. The first tassels generally appear the second week in July and corn is generally in full tassel the third or fourth week.

Rye and winter barley commence ripening about June 20 in the southeast counties, and winter wheat a few days later. Early oats and spring barley ripen almost with winter wheat, while late oats and spring wheat are two to three weeks behind.

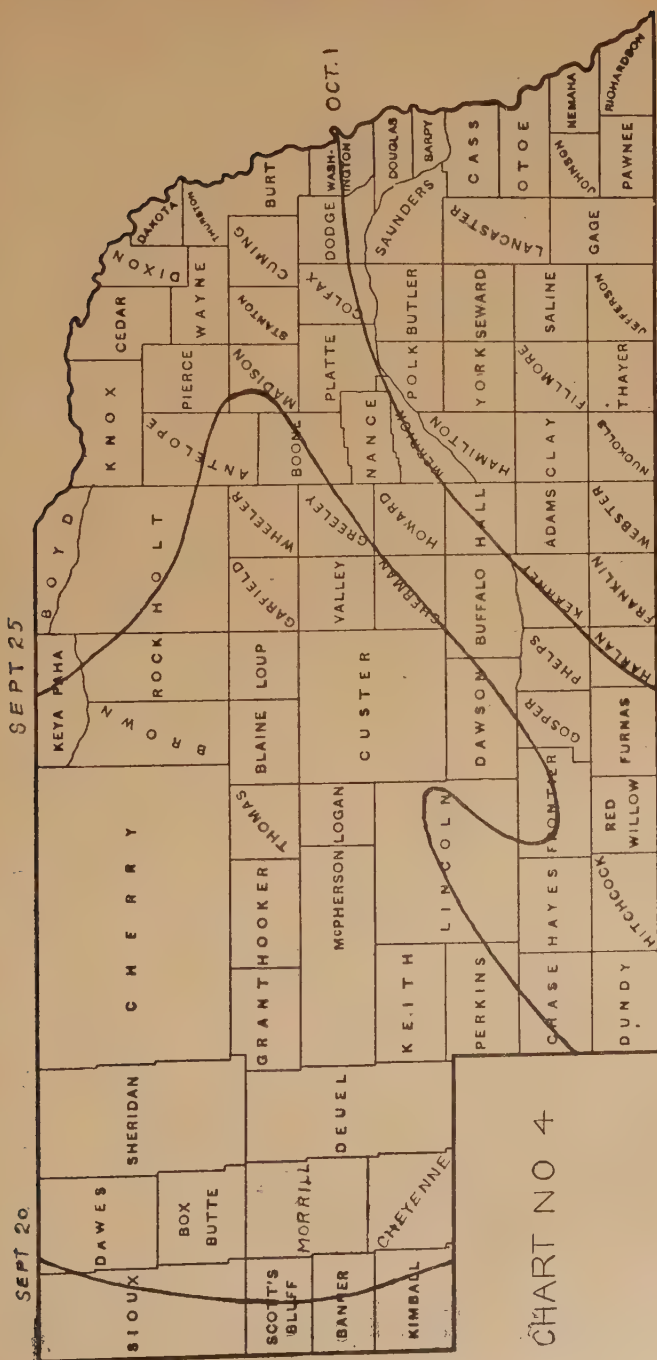
The first crop of alfalfa is ready for cutting about May 28 in the southeast and three weeks later in the northwest. Clover is ready about fifteen to twenty days later than alfalfa, and timothy is usually cut June 30 to July 15. Native upland hay is mostly cut in August, while on the river bottoms cutting begins early in July.

Winter wheat seeding begins about September 15, and the bulk of the crop is put in the last ten days in September.

The following map (chart No. 4) shows the average date on which the first killing frost in autumn has occurred. In extreme seasons the date has been from about three weeks earlier to three weeks later than the average.

The bulk of the corn is usually safe from frost by September 15, and it is seldom that extensive damage is done to this crop by early frosts. Corn husking begins from October 15 to 25, and the bulk of the crop is generally gathered by the last of November.

By the last of November the ground is usually frozen enough to stop plowing in all counties although in some rare winters plowing has been done every month.



WINDS.

The average wind velocity over the state is not very definitely known. Records have been kept since 1895 at the four weather bureau stations, Omaha, Lincoln, Valentine and North Platte. The average of the four records gives 9.8 miles per hour as the mean annual velocity. It is generally supposed that the velocity is considerably higher in the western part of the state than in the eastern, but the data, while not sufficient to determine this point, give no evidence to support the supposition. From an agricultural standpoint these records are not very satisfactory, that is, the exposures of the anemometers do not give them the same wind conditions as surround farm crops. They should be accepted as accurate measurements of the wind sweep on our fields and prairies. These records show March and April to be the windiest months with average velocities of 11.5 and 12.2 miles an hour, respectively, while July and August are the calmest months, each having an average wind velocity of 8.6 miles per hour.

Winds of thirty to forty miles an hour are not rare and higher velocities are recorded every year. These winds are nearly always straight and little damage is done, except to evaporate a large amount of moisture. While the wind velocity of the state is a serious detriment to growing crops in times of scant precipitation, it has a positive value for it pumps nearly all the water used, except in towns that are large enough to have public water systems. It is also utilized to a limited extent to run feed grinders and other small machinery. It is not often that a wind pump stands still for forty-eight hours at a time. The prevailing direction of the wind is from the south or southeast in summer and from the north or northwest in winter.

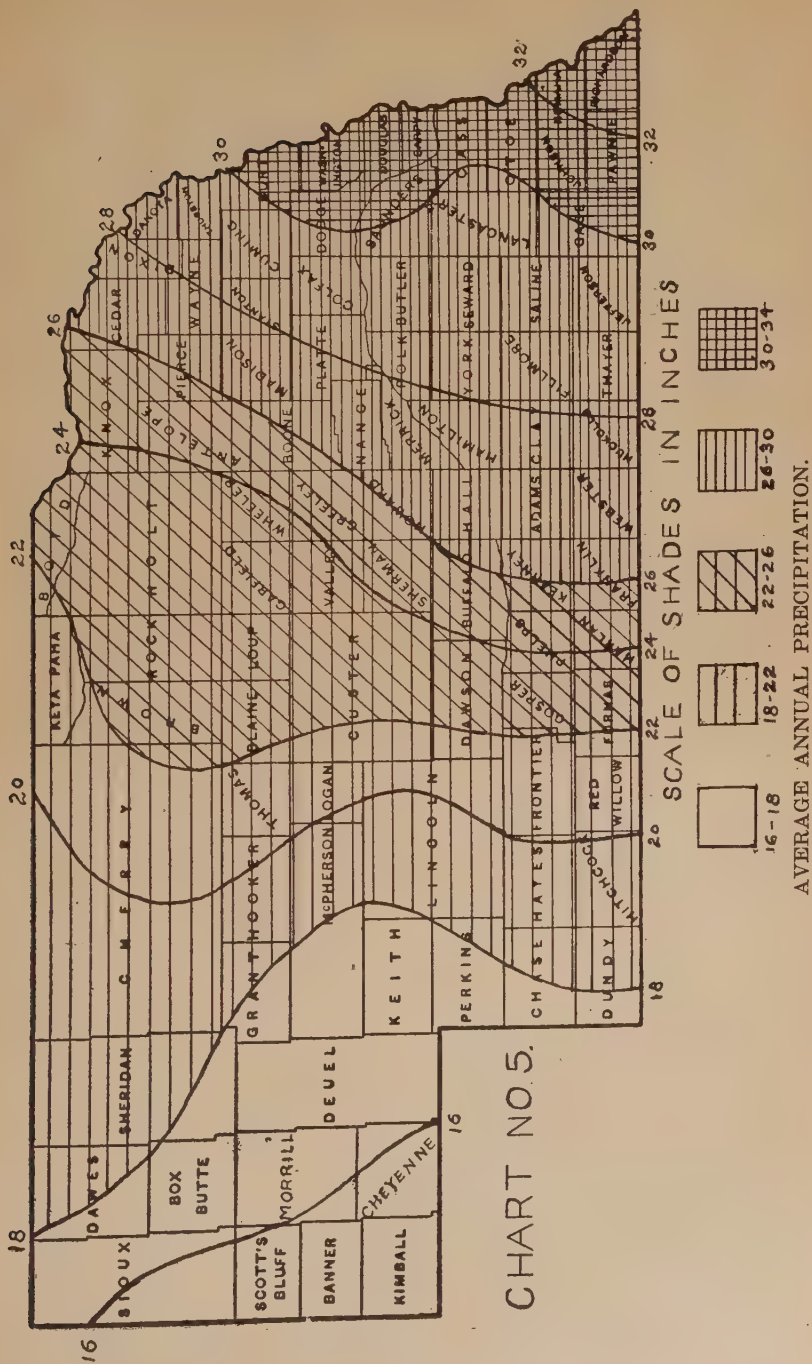
DESTRUCTIVE STORMS.

Driving winter storms sometimes occur but not with such frequency as is often supposed. The most destructive winds are the hot dry winds which at rare intervals have swept portions of the state, destroying many crops.

Nebraska lies pretty well out of the tornado belt. While a few small tornadoes have appeared within her boundaries, they are nothing like as frequent in occurrence, or as destructive in character, as in many of the states to the east and south. Destructive hail storms sometimes occur but they usually affect only small areas, and any given locality is not often visited by them except at intervals of several years. It is rarely that a single storm is able to destroy both small grain and corn. Nebraska is not peculiarly subject to hail. What data there are upon this subject indicate that Nebraska has as few such storms as any state in the corn belt.

PRECIPITATION.

The majority of our rain bearing winds are from the southeast and it seems clear that we are dependent upon the Gulf region for most of our moisture. Certainly very little moisture comes to us from the

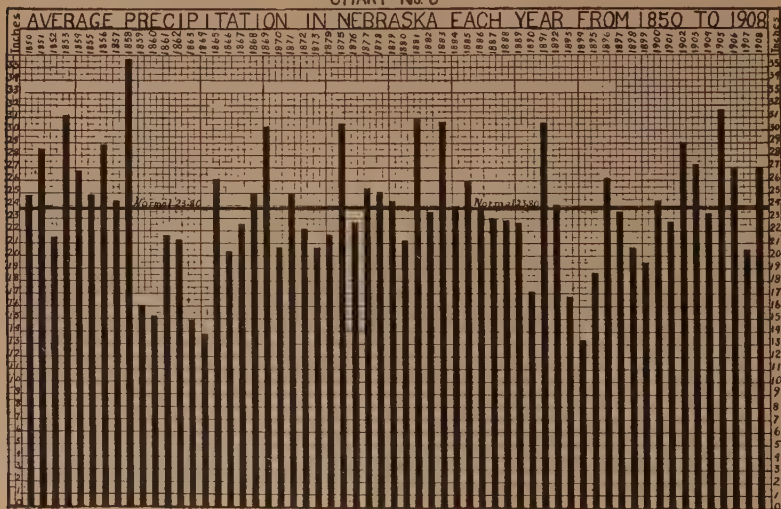


Pacific, for the winds of the west are wrung dry in passing over the Rocky Mountains.

The most of our precipitation comes in general storms during the passage of low barometer areas across the state, but local showers are also common. The average annual precipitation for the state is very unevenly distributed, varying from about thirty-four inches in the south-east corner to about fourteen inches in Kimball county in the extreme southwest, as shown by chart No. 5.

The decrease from east to west along the southern boundary seems to be fairly uniform, except possibly as the 100th meridian is approached, and averages about one inch to twenty miles. The rainfall is somewhat less in the northern part of the state, except in the north-west counties, where it seems to be influenced by the Black Hills and is greater than farther south.

CHART No. 6



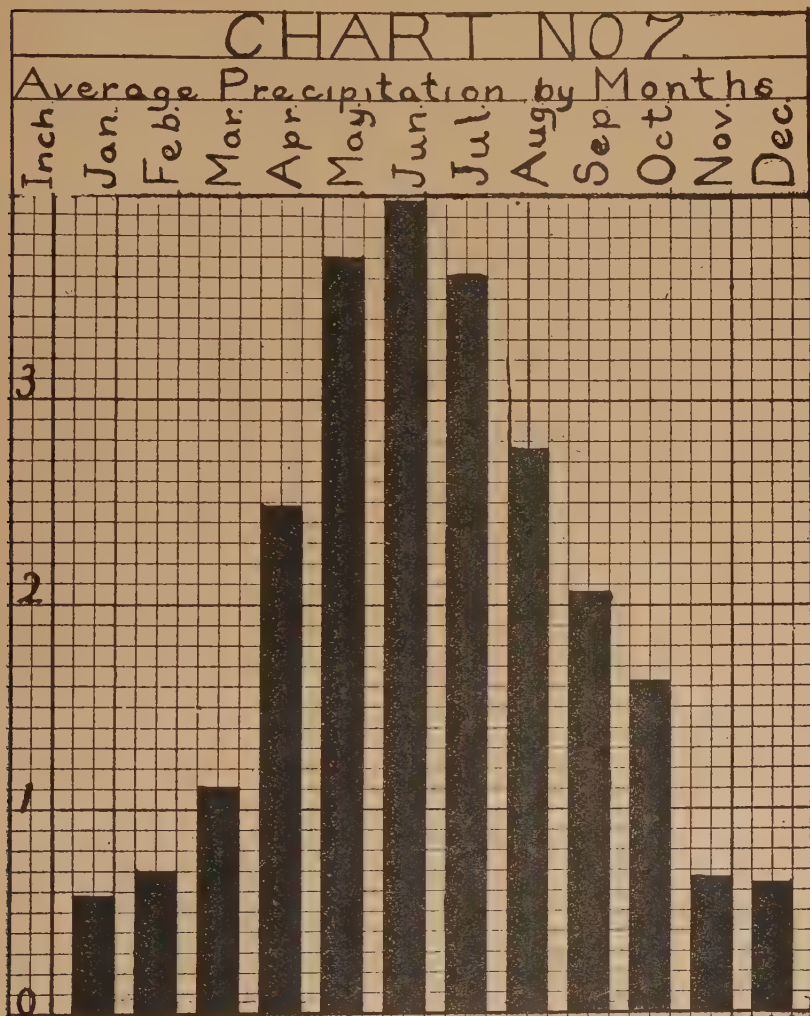
In making this chart all available data have been considered, not only for stations within this state but for nearby stations in all the adjoining states. There is a lack of data for the Sand Hill Region and for many of the western counties, but there are several good, long records in the western part of the state, and, on the whole, it is believed that the chart is as good as can be made at present, and is sufficiently accurate for practical purposes.

The average annual precipitation for the whole state for fifty-nine years, 1850 to 1908, is 23.80 inches. The average for the six equal sections, for the past thirty-three years is:

Northeast	27.84	Southwest	23.54
Southeast	30.11	Western	17.53
Central	24.89	Northwest	18.83

This mean precipitation for each year from 1850 to 1908 and the average for the fifty-nine years are shown graphically on chart No. 6.

The distribution of rainfall throughout the year is very uneven, being heaviest in June and decreasing in both directions to January, which has less than one-sixth as much as June. This is shown graphically in chart No. 7.



It must be remembered that these figures are all averages and it is not often that the rainfall for any place, or for the whole state, will be just the average. Space will not allow detailed data concerning the rainfall of particular places.*

* The record from each station up to 1895 can be found in the Report of the Nebraska State Board of Agriculture, 1895, and the data for 1896 to 1905 in the report for 1905.

In November about one-third of the precipitation falls as snow, in December two-thirds, in January and February four-fifths, in March one-half, and a very little in April. Heavy snows are not very common. The ground is not often covered to a depth of more than 6 inches, and this does not usually stay long. Considerable of the snow is generally blown into drifts, and hence does less good than it otherwise would.

With the opening of spring the increase of rainfall is very rapid and more than doubles in April. The rainfall for June is not only the heaviest for the year, but it is the most evenly distributed, the most certain and the least likely to vary widely from the normal. The fall for July is a little less than in June and not quite so well distributed. The records show three times as many periods of ten days without rain in July as in June. Beginning with August the decrease is quite rapid and fairly uniform through August, September and October. In September there are fewer dashing rains than in the three preceding months. More of the rains are steady and continue several days.

While the total precipitation for the year is light in comparison with that of many of the other states, a larger proportion of it falls during the growing season, April to August, and the rainfall of these months is much the most important of the year. "It is not the total precipitation of the year that favors vegetation (field crops as well as forests), but the amount that falls during the growing season. Thus a locality may have thirty-five or forty inches of rain annually, but if most of it falls in heavy showers or during the winter, some trees and crops will flourish less than where an annual average of but twenty inches is made up largely of moderate spring and summer rains."*

The average seasonal rainfall for Nebraska is 16.42 inches, or 69 per cent of the annual. The percentage increases from east to west, being 67 per cent at Omaha and 73 per cent at North Platte.

The comparative data in table No. 2 show that during the growing season the rainfall in much of Nebraska is fully equal to that of the states farther east.

TABLE NO. 2.—*Seasonal Rainfall, April to August. Bulletin D, U. S.*

	Weather Bureau.	Minimum for Years. Six Months.
Cincinnati, O.,	19.4	62 11.9—1870
Indianapolis, Ind.,	19.6	27 10.9—1870
Peoria, Ill.,	17.7	41 10.4—1870
Ames, Ia.,	18.9	21 13.0—1886
Ithaca, N. Y.,	15.8	36
Omaha, Neb.,	21.1	37 11.1—1894
Genoa, Neb.,	19.8	32 11.1—1894
North Platte, Neb.,	13.4	33 8.0—1869

* W. F. Hubbard, U. S. Weather Review, Jan. 1906, p. 24.

By examining the record of annual precipitation we find that there is a wide variation from year to year. From 1876 to 1907 it has varied from 57 to 135 per cent. of the normal. We may expect the variation at any particular place to be greater than the average for the state. Because in averaging the state deficiency in one locality is often equalized by excess in another.

If we examine the record from 1850 to 1908, fifty-nine years, we find:

Six very dry years (less than 70 per cent of the normal).

Ten dry years (from 71 to 90 per cent of normal).

Twenty-nine normal years (from 91 to 110 per cent of normal).

Eleven wet years (from 110 to 130 per cent of normal).

Three very wet years (over 130 per cent of normal).

In discussing this point and comparing the Nebraska record with the longest known records, Buda 176 years, Milan 137, Klagenfurt 88 years, Mr. G. A. Loveland says: "The conclusion seems to be a safe one that the number of wet and dry years in Nebraska will bear about the same ratio to each other and to years of normal rainfall as might be expected in most parts of the world."* This is not saying that Nebraska is or is not more subject to damaging drouths than the Eastern states. In much of the state the normal precipitation is very near the minimum limit for crop production, and in many western counties the normal is even below that limit, and profitable crops are produced only in the wet years. A reduction below the normal then is a much more serious matter than if the normal was far above the necessary amount.

Many people have gained the impression that the rainfall has increased since the state was settled and that cultivation of the soil has brought more rain. Statements to this effect have often and unwisely been published.† A careful examination of the record shows that 1849 was by far the wettest year of the sixty, and that the wettest ten-year period was 1849 to 1858, while in 1854 there was not more than a square mile of land under cultivation in the state.‡ The next ten-year period was the driest, but only a little drier than the ten years from 1892 to 1901.

We may reasonably expect a succession of wet years or a succession of dry years, but these fluctuations do not occur with any regularity. During the ten years from 1849 to 1858 only one year had less than normal precipitation; of the next eighteen years, 1859 to 1876, only five had more than normal precipitation; of the nine years, 1877 to 1885, only two were below normal, then follows a period of fourteen years in which only two were wet, and of the last nine years, 1900 to 1908, four have been considerably above normal and none seriously dry. From this we should expect a number of years in the near future with less than normal rainfall.

* Climatic and Crop Service of U. S. Weather Bureau, Nebr. Section, Sept., 1902, p. 3.

† Resources of Nebraska, State Bureau of Labor and Industrial Statistics, Oct., 1904, p. 9.

‡ Hon. J. Sterling Morton, Rept. of Nebr. State Board of Agri., 1905, p. 205.

RUN-OFF AND EVAPORATION.

Practically all the water that falls upon the land must eventually run off in the streams or be evaporated into the air. The water which flows off in the streams either runs off directly from the surface as storm water, or soaks deep into the earth and reaches the streams through springs and seepage areas. In either case it is the excess that flows off, the part that the soil can not hold. This is not a loss for its presence in the soil is no benefit but a detriment to plants. Furthermore, it washes out and carries away with it plant food. The less water to run off the better.

The rain water which does not run off from the surface or seep out through the springs is caught by the soil and held until it is evaporated into the air, either directly from the surface of the soil or indirectly from the leaves and stems of plants. This is the water that is available for plants to use, and it is this and this only that is of any benefit to plants. It is the amount of water the soil holds and delivers to plant roots and not the amount that falls upon it that most concerns the farmer.

The amount of run-off from any region is influenced by many complex conditions, among which are the amount and rapidity of rainfall, the texture and depth of the soil, the slope, the plant growth, the geological formations, the winds and the relative humidity of the atmosphere.

The soil of Nebraska is mostly porous and very deep. It absorbs water rapidly, holds it well and gives it up readily to plants. The slope of the land is generally not great; the average wind velocity is high; the average relative humidity is low. All of these conditions combine to make the run-off small and the evaporation great.

The run-off for the state has commonly been estimated at one-tenth of the rainfall, and this is probably very nearly correct. The gagings of the Niobrara river at Valentine show about 10 per cent of run-off; those of the Blue river at Manhattan, Kan., 11 per cent; of the Loup river at Columbus somewhat higher; of the Republican river at Junction City, Kan., not over 3 per cent. The high run-off of the Loup river is no doubt due to the fact that a large part of its basin is sand hills, where the soil is too coarse to hold as much water as the finer soils and so porous that more of it sinks deep and gets beyond the reach of evaporation and plant roots. A large part of the Republican river basin lies in the semi-arid plains of Colorado. The Blue river basin is taken as an example because it lies wholly within a highly agricultural region, most of which is within the state, and the data for the rainfall and run-off are more complete than for any other basin. To get the precipitation for the basin the means for these years for Hastings, Edgar, Fairmont, Seward, Hebron, Beatrice, Nebr., and Manhattan, Kan., have been taken. These stations represent comparatively equal areas and give a very accurate average for the basin. The figures for the run-off have been copied from U. S. G. S. Water Supply Paper 96. The column headed "evaporation" is obtained by subtracting "run-off" from "precipitation."

TABLE No. 3.—*Run-off, Precipitation and Evaporation for Blue River Basin.*

Year.	RUNOFF IN INCHES.												Precipitation.	Evaporation.
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l	
1896	.07	.06		.13	.59	.55	.67	.31	.19	.13	.14	.09	2.93	32.85
1897	.12	.14	.17	.93	.28	.35	.31	.21	.07	.07	.08	.09	2.96	28.97
1898	.08	.23	.09	.18	.43	.53	.09	.06	.04	.04	.06	.07	1.90	23.31
1899	.09	.09	.22	.11	.49	.56	.32	.18	.06	.07	.07	.07	2.33	22.80
1900	.08	.06	.17	.17	.33	.11	.31	.12	.21	.09	.09	.07	1.81	26.77
1901	.08	.17	.14	.26	.14	.10	.06	.09	.06	.06	.07	.06	1.29	22.68
1902	.06	.07	.08	.06	.27	.74	2.05	.53	.59	.61	.22	.23	5.51	36.24
1903	.18	.26	.60	.12	2.42	1.93	.32	1.16	.30	.16	.21	.13	7.79	28.85

The column headed "evaporation" is obtained by subtracting "run-off" from "precipitation."

This shows a variation from 5.3 per cent of the rainfall, 1901, a dry season, to 20.8 per cent in 1903, a wet year. The run-off for May alone in 1903 was more than the total for four different years, and yet it was less than 20 per cent of the rainfall (12.82 inches) for that month. Much of the rainfall for May was, however, carried over and delivered in June, but the run-off for the two months was only 4.35 inches or 28 per cent of the rainfall, which was 15.35. The next highest run-off, 2.05 inches, occurred in July, 1902, but the rainfall of that month was 10.12 inches, making the run-off only 20 per cent. This month, too, was preceded by a very wet June (9.34 inches) with comparatively little run-off (.74 inches). The run-off for the two months was only 14 per cent of the rainfall. These were periods of excessive rainfall and even then the run-off was small in comparison with that of eastern streams.

TABLE NO. 4.—*Run-off, Rainfall and Evaporation for Different River Basins.*

River.	Years Observed.	Area of Basin.	Rainfall.	Run-off.	Evaporation.	Per cent of Run-off.
Muskingon, O.*.....	8	5.828	39.7	13.1	26.6	33
Genesee, N. Y.*.....	9	1.070	40.3	14.2	26.1	35.2
Hudson*	14	4.500	44.2	23.3	20.9	52.5
Connecticut*	11	10.234	43	22	21	51.2
Blue†	8	9.490	31	3.31	27.7	10.6

Not only is rainfall greater for the growing season in Nebraska than farther east, but, as shown by the table, the total amount of water evaporated to the air from the soil and from plants is greater than in Ohio, New York or New England. The influences bringing about this evaporation have already been mentioned.

These figures do not by any means represent the possible evaporation. In dry spells evaporation often becomes slow or ceases entirely for want of something to evaporate. What the evaporation is from open water surfaces is not very definitely known, but is probably about 40 inches at Omaha and 55 inches at North Platte. It is quite certain that evaporation from an open water surface increases considerably from east to west across the state.

GEOLOGY.

From an agricultural standpoint the geology of a region is extremely important because it has been the most important factor in determining the soil and topography, and, therefore, the agricultural possibilities. The occurrence of coal and building materials, such as stone, clay and sand, are entirely dependent upon the geology, and the supply and quality of water in wells, springs and streams is largely determined by

* U. S. Geological Survey, Water Supply Paper 96.

† Data on run-off obtained from Nebraska State Engineer's office.

the layers of sand, clay and rock beneath the surface. So well recognized are the relations of certain geological formations to water that in most of this state well diggers depend implicitly upon their knowledge of the strata. For example, in Nebraska they always expect to find water at the bottom of the loess or drift, and the experienced digger will always stop when he strikes Pierre shale. He has no hope of finding water in it.

For our purpose the most important geological formations are those which are exposed over the largest areas—those from which most of the soils of the state have been formed. While many different formations are exposed within our borders, those which have produced the soil over large areas are few in number and of comparatively recent origin. Over most of the state the exposed formations are so deep that we do not concern ourselves about what lies beneath.

In ages past, parts of the territory which Nebraska now includes have been covered by seas, lakes and glaciers. During each period deposits peculiar to that time and condition were laid down, only to be washed and furrowed, and finally buried by later deposits. In the southeastern part of the state many of the newer deposits, if ever laid down, have been washed away, and so the oldest rocks within our borders are exposed there.

Rocks of four different systems, comprising Carboniferous, Cretaceous, Tertiary and Quaternary ages, outcrop to greater or less extent in various parts of Nebraska. Rocks of Carboniferous age, composed mostly of limestones and clay, outcrop along the Missouri river from Blair south, along the Platte below Ashland, and along nearly all streams east and south from Lincoln and Beatrice. These are the oldest formations exposed in the state and they have been almost entirely buried by later deposits. They now appear at the surface in small patches on a few hilltops in Richardson and Pawnee counties and along the banks of streams where the water has carried away the younger strata and left the old rocks bare. They have not formed the soils except in small patches, which are frequently so stony as to be fit only for pasture. Their importance lies mainly in the limestone which is quarried at many points, the clays which are used for brick and tile, and in their relation to well water. Some thin veins of coal are also found in them.

Next in age comes the Cretaceous, which is represented by many layers of sandstone, limestone, shale and clay. Dakota sandstones, sands and clays outcrop occasionally from Jefferson and Gage counties north-east to Dixon county. The rusty sandstone near the penitentiary at Lincoln, south of Fairbury, at Ashland, and other points is representative. This stone is used to some extent for building purposes. It is very porous and where luried under other formations is usually saturated with water of fair quality. It is in this formation that most of the artesian wells of Nebraska, Dakota and southeastern Colorado are sunk. Dakota clay is used in brick and pottery work. The Dakota is

buried except in very limited areas and so has produced the soils in only a few small patches, most of which are sandy and of inferior quality.

The Granerose, Greenhorn and Carlisle formations are of little importance in this state. They outcrop in small areas in Dixon, Dakota, Seward, Jefferson and Thayer counties. Some of the clays of these formations are used in brick work, and the Greenhorn limestone is quarried in several places. This is the "fence post" stone of Kansas. This limestone breaks down into black clay, a rich soil of which only a few small patches are known in this state. The Carlisle shale forms a blue-gray to slate colored "gumbo" soil of poor quality. The Blue Hills north of Plainville, Kansas, are composed of this shale.

Niobrara Formation.—This formation is represented by the chalk rock along the lower Niobrara river and the Missouri river from Dixon county up, also along the Republican river from Harlan county east. This chalk is used some for building, and together with the Pierre shale, which lies above it, forms an excellent cement material. The outcrops do not cover any considerable areas and as a source of soil have no importance. What soil has been produced from the Niobrara chalk alone is usually light colored and not very productive, but debris at the foot of chalk cliffs supports a vigorous growth of plants.

Lying upon the Niobrara chalk is the Pierre Formation, which consists of dark, slate-colored, gray or yellow shale or clay, often called soapstone, gumbo rock and blue clay. Sometimes there are thin layers of chalk in it. A deep bed of it underlies all the western part of the state, but fortunately in most places it is buried deeply by later deposits. In breaking down the Pierre shale forms stiff, sticky clay, which is the gumbo of northern Sioux, Dawes, Keya Paha, Boyd, Holt and Knox counties. The soil formed from it is usually very fertile where there is sufficient moisture, but is extremely difficult to till and often contains damaging amounts of alkali and other minerals. The Pierre shale delivers very little water to wells and what is found in it is generally unfit for use.

Brule.—In the western part of the state overlying the Pierre shale beds, are the White river formations, chief of which is the Brule clay. This consists mostly of yellowish to pinkish clay and sand. The White river, the North Platte, the Pumpkinseed and the Lodgepole have all cut their valleys through the Loup Fork beds and exposed the Brule deposits in considerable areas. These deposits are very easily eroded and form the typical bad lands of northern Sioux and Sheridan counties. Especially where capped with the harder rocks of the Loup Fork it gives rugged topography, which becomes really mountainous on the divide between Gering and Harrisburg. The Brule clays lie in a very compact mass, sometimes almost stony, and weather into all sorts of fantastic shaped buttes, such as Court house and Jail rocks at Bridgeport, Chimney rock at Bayard, and hundreds of others, especially in northern Sioux and Dawes counties. Where the material from these beds does not wash too much it forms productive soil.

Loup Fork.—After the Brule clay was deposited, large quantities of gravel, sand, silt, clay and lime washed from the Rocky Mountains by rivers were spread over all western Nebraska. This is the Loup Fork beds which are now on the surface and have formed the soils west of the sand hills, except where the streams have cut through and exposed the Brule clay and the Pierre shale. North of the Platte river these beds have been known as the Arikaree formation and south of it as the Ogallala and the Mortar beds.

In the Ogallala deep beds of limestone, usually sandy, and soft lime and sandy lime are frequent. Both of these formations are strikingly ununiform in character and contain beds of clay, sand, gravel and limestone in no conceivable order and of no regular shape, and often beds of all these materials mixed, but sand is nearly always predominant. In consequence we find in these areas many variations in soil and topography, according to what kind of material predominates at that particular point. Both formations have furnished material for sand dunes, and from them the sand hills of the Plains Region have been mainly derived. Most of the Loup Fork beds are easily eroded and as a rule streams have cut deep valleys through them.

Where beds of fine sand, silt and clay are exposed, these formations have broken down into rich soils which would be of much greater agricultural importance if it was not for the aridity of the climate. A good supply of water for domestic use is usually available, but often at considerable depth.

Glacial Drift is the material dropped by the ice sheet that covered eastern Nebraska in ages past. It consists of particles of clay, sand, gravel and boulders dropped down in the most helter-skelter fashion. In places there are beds of almost pure clay, beds of nicely sorted sands of different sizes, beds of gravel and of boulders, while in other places all these materials are mixed in the greatest confusion. This drift covered all eastern Nebraska but is now buried under loess except in Johnson, Pawnee, Lancaster, southern Jefferson, western Richardson counties, and small outcrops in the other eastern counties.

Loess.—After the Loup Fork beds had been deposited over western Nebraska and the glacier had finished its work in the east, a deep deposit of silt, clay and fine sand was laid down by the wind or water or both. This is the loess. It is typical in the high bluffs at Omaha and Blair and on the level prairies at Fairmont and Holdrege. A line from the mouth of the Niobrara river southwest to the southwestern corner of the state in Dundy county approximately marks the northwestern limit of this deposit. With the exception of the river bottoms, and some other comparatively small areas, loess covers all the state to the south-east of this line.

This is by all means the most important deposit of the state, not only because of its extent but because of the remarkable fertility of the soil which it forms. This and similar deposits have furnished

most of the soil of the great corn belt, and of parts of Germany and China, renowned for their fertility.

Loess is extremely uniform in texture for a deposit covering such a wide area. It is made up of a large proportion of silt and usually a small proportion of fine sand and clay. The amount of clay is seldom over 30 per cent and fine sand less than that proportion except near its northwestern limit and in some local areas. This deposit is easily eroded and streams flowing through it have mostly cut broad valleys with more or less sloping bluffs.

To the west of the loess lies one large area of sand hills and several smaller ones, covering a total of probably 18,000 square miles. These areas are covered mostly by wind blown sands, piled in rounded hills of all shapes and sizes and rising from a few feet to 300 feet from their bases. The origin of these sands is somewhat uncertain, but their presence is a vivid reality, especially to the traveler who finds himself alone in their midst. Besides the large area of sand hills north of the Platte river, there is a well defined area in Pundy county extending into Colorado, and one south of the Platte river in Lincoln county. Besides these sand hill areas proper, there are several small areas of dunes made up of fine sands, most of which appear to have been blown out of the rivers which have their sources in the hills. Such belts are found south of Kearney, north of Grand Island and west of Columbus.

Alluvium.—Most of the streams of the state, as has been mentioned, have cut broad valleys. These valley floors the streams have covered with sediment which they have brought from higher levels. This sediment, or alluvium, composed of clay, silt, sand, gravel and organic matter, usually forms excellent agricultural soils. The area of these deposits is not known but it is certainly several thousand square miles.

TOPOGRAPHY.

While Nebraska lies entirely within the Great Plains, its surface is far from being a smooth plain, but presents all variations in topography from level prairies to deep canons and gorges, and rugged hills and buttes of mountain height.*

From all appearances we must conclude that after the sandy deposits of western Nebraska were laid down, the surface of most of the state at least was a comparatively smooth plain. The glacier which later covered the eastern counties, however, left that region more or less hilly, and in places the plowing and piling done by the ice have been important factors in shaping the present topography. After the glacier melted away the loess was deposited over all or nearly all the eastern part of the state, and lapping far out on the Loup Fork beds to the west, leaving a smooth surface. But since that time the winds and the waters have worked great changes. The winds have blown the sands into hills; they have gathered dust in one locality and dropped

* Geography of Nebraska, by G. E. Condra.

it in another, very slowly, it is true, but none the less surely. In places they have dug out basins and in others have carried away the loose materials and left high buttes, and are still carrying on this work. Rivers have been cutting their valleys deep and wide and then redepositing sediment to cover their valley floors. The water from rains and snow has run down these slopes, cutting, at first, very little channels, which grew deeper and deeper and wider and wider as streamlets united and the volume and power of the water increased till the main rivers were reached. The sides of the channels were rounded off into rolling hills and gentle slopes. This process is still going on.

The eastern part of the state is much the most completely worn into rounded hills, partly, at least, because it receives much the heaviest rainfall. Soils that are loose and dry on the surface are more easily blown than others, and therefore wind action has had the most marked effect in the drier and sandier sections, especially in the sand hill region and in the buttes of the Platte and White river bluffs.

On account of the difference in texture of the different formations exposed, as well as the difference in climate, erosion has not had the same effect in all sections. This has brought about the recognition of four general topographic regions corresponding with the geological regions—the Loess, Sand Hill, High Plains, Bad Lands—established by the Nebraska Geological Survey.

The Loess region is characterized by hilly, rolling or level prairies, covered by a heavy growth of tall grass and belts of timber along the streams. Sand dunes and basin-shaped valleys are the characteristic forms of the Sand Hill Region. The High Plains Region is marked by level, fine sandy plains, covered by short grass, sand ridges and loamy valleys. The Bad Lands Region is marked by wind- and water-formed buttes and barren tracts of clay, which are devoid of vegetation, mainly on account of the rapidity with which they are eroded. From an agricultural, industrial or scientific standpoint, each of these regions naturally divides itself into several different areas which grade more or less insensibly into one another. The bluff areas along the Missouri and in places along the Platte and other streams, consist of hills with mostly steep slopes and rounded tops, often rising from 200 to 500 feet within a mile or two of the river bottoms. They do not usually extend more than one to three miles back. These areas on account of the steep slopes and their liability to wash, are not well adapted to general farming, but are better fitted for producing fruit, timber and pasture. In these areas wagon roads wind between the hills and railroads follow the water courses.

The rolling prairies include all the area where glacial drift is exposed and a larger area of loess soil, especially north of the Platte river. This area is gently rolling to heavily rolling and in some places rough and hilly, but is nearly all tillable and well suited to general agriculture. There are, however, some small areas so rough as to be of little value except for grazing. In all of these areas drainage is too rapid, resulting

in washing and gullyng of the fields. In many places the water courses have cut through the loess and glacial drift is exposed on the slopes, while loess caps the hills. In some sections, especially in parts of Lancaster, Johnson, Pawnee, Jefferson and Richardson counties, the loess, if ever deposited, has been entirely removed.

These level plains south of the Platte and the rolling prairies north of that stream grade off on the west into an area which is characterized by level, loess tables separated by canons or steep-banked ravines, often over 100 feet deep, and frequently with precipitous walls. The drop from the level upland to the canon bottom is often a sheer precipice, with little or no sloping approach, and the traveler sees no evidence of its presence till he is fairly upon it. These high banks are due to the peculiar tendency of the loess to assume a columnar structure. In this area we must include much of Custer, Dawson, Buffalo, Gosper, Harlan, Frontier, Hayes, Hitchcock and parts of other counties. Railroads are confined to the river bottoms, and wagon roads in many places are compelled to follow the canons. Travel across the general direction of the canons is sometimes very difficult.

The main Sand Hill Region with its outlying areas are successions of rounded dunes with saucer-shaped basins of varying sizes between, or are connected into ridges or chains, separated by valleys. Looking across them one gets the impression of an endless sea of sand billows rising to an almost uniform height.

In the High Plains Region there are extensive level tracts in Grant, Cheyenne, Deuel, Kimball and Box Butte counties. Much of this region is covered with sandy soil which blows into low sand ridges and leaves loamy valleys and level lands between. In some places, especially in Sioux county and along the borders of most of the streams, there are rolling to rough, sandy, gravelly hills. As the South Platte river and the Frenchman and Lodgepole creeks are approached, the smooth tables gradually give way to rolling and rough, often gravelly, hills, and sometimes to high escarpments of limestone.

In approaching the Pumpkinseed and the North Platte from the Cheyenne Plains, we see first a heavily-rolling country, sometimes canony, which in places gives way to very rough and precipitous hills and buttes, and in a short distance we go down 500 to 1,000 feet to the valley bottoms. The divide between the Pumpkinseed and the North Platte is very rough, rocky and cut by many canons and deep ravines. For about fifty miles there are few wagon roads across it. Wildcat and Hog's Back mountains and Scott's Bluff are outposts of this range. West of these points the divide broadens and is less rugged.

North of the North Platte river and west of the sand hills is a region of broken country, presenting some smooth valleys and tables but largely occupied by steep hills, consisting largely of sand, gravel and limestone.

On the north of the Snake river is a smooth prairie known as the Box Butte plains, which in every respect resembles the Cheyenne plains. It

comprises most of Box Butte and parts of Dawes and Sheridan counties. This plain is limited on the north by Pine Ridge, a high escarpment formed by the Hat creek and White river cutting away the surface to the north of it.

Pine Ridge is a rough and rugged region of steep hills and buttes, usually capped with Arikaree sandstone and often separated by valleys of considerable width. The north slope of Pine Ridge is the Bad Lands. The White river and Hat creek having cut down through the Arikaree and the White river beds have exposed a considerable area of the latter, which are made up mostly of light-colored, sandy clay which erodes very rapidly. It is this clay that colors the water of the White river and gives that stream its name. The rapid erosion prevents the growth of vegetation, except in the leveler places, and gives the rough, barren bad lands. There is also a very small bad lands area at the foot of Scott's Bluff on the North Platte river.

Valleys.—The streams of the state, as a rule, flow through broad, smooth valleys, especially in the Loess Region. The Missouri through most of its course along the eastern boundary of the state keeps close to the Nebraska bluffs, so its bottom land is mostly on the Iowa side, but in the vicinity of Dakota City, De Soto and Peru there are considerable bottoms on the west, which form a striking contrast to the high bluffs which rise directly from them.

The valley of the Platte is the most extensive. From near Ashland, where it enters the limestone beds, to the mouth there is very little valley, but above Ashland the valley broadens rapidly until a width of about twenty miles is reached, where the Loup enters the Platte valley north of Grand Island. From this point it is eight to twelve miles wide to about Gothenberg, then a little narrower to about ten miles above the confluence of the North and South Plattes. Above this point the valleys are only one to three miles wide. In several places, especially in Buffalo and Scott's Bluff counties, there are extensive benches, terraces or second bottoms. The water channel is a broad strip of sand, only a few feet below the valley floor, through which the stream flows in shallow, interlacing streams. The Platte has been facetiously, and with much truth, described as a "mile wide and an inch deep."

Salt creek and its branches have valleys about one-half mile wide above Lincoln, but there the united valley widens and is one to three miles wide to its mouth. The hills slope back gradually much of the way, but near the sources of the tributaries in western Lancaster and southwestern Saunders counties the hills are steep and high and strewn with glacial boulders, making them of little use except for pasture.

The valleys of the Loups are generally about a mile wide from the point where they leave the sand hills to where they join the Platte. Most of the way the bluffs rise quite suddenly from the bottom lands. The channels are cut deep below the valley floors.

The Elkhorn valley varies from one to three miles in width. In most places the hills slope back gradually, but in some places they rise into bluffs.

Of all the streams of the state, the Logan creek probably has the broadest valley for the size of the stream. This valley is one to three miles wide up to near the source of the creek.

The Pumpkinseed creek, which is a tiny stream only a few feet across, occupies a sloping valley two to four miles wide and 500 to 800 feet deep, with steep and rugged bluffs.

The valley of the Big Blue is generally three-fourths to one mile wide from the north and west lines of Seward county to the south line of the state. The channel is ten to twenty feet below the flood plain and the bluffs are sloping hills, most of which are tillable.

The valley of the Little Blue from Adams county down is about one-half to one mile wide, and in most places the bluffs are steep and rough.

The Nemahas run through valleys one-half to one and one-half miles wide. The channels are ten to twenty feet below the valley floors, and the bluffs are mostly either gently sloping or rather steep hills. Where limestone outcrops, as from Tecumseh to Dawson, the valley is narrower and the bluffs often become ledges.

The Republican valley is one to three miles wide, usually nearer the smaller figure. Through most of its course the bluffs are steep on one side. A large part of the valley is in terraces.

The valleys of the Prairie Dog and Beaver are one-half to one and one-half miles in width and the bluffs, while sometimes steep, are often only sloping hills. The creeks have channels considerably below the valley floors, which often assume the character of benches rather than first bottoms.

The valleys of the Frenchman and Medicine creeks are about one-half mile wide and bordered by steep bluffs intersected by many canons.

The Niobrara through most of its course has cut only a narrow valley, 200 to 600 feet deep, with steep bluffs on both sides. The valley floor is seldom more than one-half a mile in width. In Sioux and Dawes counties the valley is not deep and the land slopes back from it gradually. The valleys of the Keya Paha and Ponca creeks are narrow and much resemble that of the Niobrara near by.

In many parts of the state topographic control of crops is very marked and will be discussed under the respective crops.

ALTITUDE AND SLOPE.

The state is a portion of the great slope which extends eastward from the Rocky Mountains, and varies in altitude (height above sea level) from about 800 feet in the southeast corner to over 5,300 feet near the Wyoming line in Kimball and Banner counties. The average of the uplands near the Missouri river is about 1,100 feet, and along the western boundary about 4,700 feet.

The eastward slope is much more rapid in the western portion than in the east, being about ten feet per mile for the western third, seven feet for the central third, and six feet for the eastern. The eastern part of the state also has a slight slope to the south, as is shown by the Elkhorn, Blue and Nemaha rivers. The slopes of the Platte and other valleys are considerably less than of the plain, for some of these valleys are cut about 1,000 feet deep in the western part, while the Missouri is only 100 to 200 feet below the level of the uplands. The slope is important only because it has determined the direction and velocity of streams; and so indirectly has largely determined the topography and influenced the location of railways and the directions which they take. From our standpoint the only importance of the elevation lies in its effect upon climate. As the altitude increases the temperature decreases; frosts come later in the spring and earlier in the fall and so make the season for growing crops shorter. When the temperature is the same, water evaporates faster in higher altitudes. This means that the farmer may need to take more care to cultivate to keep moisture in the soil, but it favors him in haying time by drying the crop more quickly.

DRAINAGE.

Most of the farmers of the state have no drainage problem, for drainage is more often above than below the needs. On most farms erosion does more damage than deficient drainage, and yet, in the aggregate, many thousands of acres are at present untillable because of deficient drainage. The amount of land that needs drainage is probably fully as great as that which needs irrigation and can be watered. All the run-off water finds its way either directly or indirectly into the Missouri river. A small area drains directly into the Missouri river, but most of the waters reach it through other streams.

Over most of the state the exposed formations are composed of a large percentage of loose, porous silt or sand to an average depth of probably 100 feet, and only a small per cent (rarely more than 30) of clay. These porous soils and subsoils absorb water rapidly and allow it to penetrate to a great depth. In most cases there is sufficient surface drainage to carry off what excess of water there may be, but in many places in the river valleys, on the Loess Plains, the High Plains and in the Sand Hills surface drainage is deficient.

On the level plains the water finds its way into intermittent ponds or lakes, usually called "lagoons." These are usually small, but a few are known which cover several square miles. The smaller ponds catch the water from only a small basin surrounding them but some of the larger ones receive the discharge from draws several miles in length. These ponds occur on all the level prairies, but are most numerous in Phelps, Clay and Fillmore counties.

The total area of these ponds is quite large. Phelps county alone probably has over 10,000 acres thus rendered useless for field crops.

This land, however, is not entirely waste, for, except where covered with water most of the time, native wheat grass produces some pasture or one-half to one and one-half tons of excellent hay to the acre.

Here is a large and important field for artificial drainage which has as yet been touched in only a few places. In some places drainage is economically impossible, but in many instances it is an easy matter. Often a ditch or tile a few rods long would drain several acres. In other cases extensive drainage systems could carry the water from large numbers of ponds to a common outlet at a small cost per acre. Many can be drained simply by open ditches, but the bottoms of the larger lakes are so level and the soil so heavy that tiling will probably be necessary.

The soils of these ponds are of excellent quality. They grade as clay and clay loam, being made up largely of the finer particles washed in from the surrounding fields. While a little hard to bring to a good state of cultivation, they are very productive. The percentage of humus is very high in many of them, especially in the wetter parts, and large stores of nitrogen have been added by the countless swarms of fowls and amphibians that have frequented them from time untold. There is usually some alkali in these soils, but not enough to be destructive to common crops. The only serious question is drainage. The land bordering these ponds is worth \$50 to \$125 an acre and the writer sees no reason why this marsh land should be worth any less when thoroughly drained.

On the high plains, especially the Cheyenne and the Box Butte plains, there are large areas too level to drain well, but here drainage is of little importance because the limited amount of rain that falls is usually absorbed at once by the porous soil and there is no run-off, except during an occasional torrential downpour. The annual discharge of the Republican river calculated from measurements taken at its mouth would make only about sixty-five hundredths of an inch over its entire drainage basin, and the run-off of these plains is probably about the same.

On these plains are seen depressions similar to those described on the loess plains, but they seldom hold water long because of the aridity of the climate. On account of the low value of land and the small percentage under cultivation, such ponds are of little importance.

Along nearly all the river valleys is much land that lacks drainage and tiling and ditching must be resorted to. Drainage districts have been formed and considerable work has been done in the last few years along the Nemahas, the Missouri, Elkhorn and Logan creek, but only a start has been made. Until recently the state laws were very unfavorable to this work. Nearly everywhere outlets to the rivers can be had at no great distance, and considering the high prices of land and the wonderful possibilities of these soils, it would seem clear that this work should be pushed to its utmost. Thousands of acres of land can thus be reclaimed and at a cost far below the increased value that would accrue to them.

Some of the streams frequently flood their valleys, doing much damage to crops. This is especially true of the Nemahas. Ordinarily these streams are confined to narrow channels, ten to twenty feet below the valley floors. But the drainage basins of these rivers are mostly rolling or hilly, and after heavy rains in wet periods the water rushes into the streams and sends them out of banks. This could be largely but not entirely remedied by clearing the channels of obstructions. These streams are well timbered down to the water's edge, and stumps and fallen trees often obstruct the course even in times of low water, and in times of high water the interference is serious. The channels should be cleared of trees and stumps at least to the tops of the banks. This would probably double their capacity and be an immense help in flood times.

In the sand hills there is no definite system of surface drainage. What streams there are have a continual struggle with the sand to prevent their channels being closed and many streams have been obliterated entirely. Snake creek, south of Alliance, shows this. Sand-hill streams rarely have any tributaries but are fed entirely by seepage. On this account they are extremely constant in volume and practically unaffected by storms. The slow movement and the long journey which the water takes through the sand equalizes the discharge.

In the hills are many basins surrounded by loamy soils which receive a little surface water and form intermittent ponds. The most striking feature of the sand hill drainage, however, is the lakes. The sands are usually not deep in the valleys and the whole region is underlaid by more or less impervious beds. The water table stands above the bottoms of many of these valleys and basins, forming perennial lakes. The water in these lakes is observed to rise in the fall as it also does in the streams. This curious phenomenon is no doubt due to the checking of evaporation by the lower temperatures, and it is probable also that the water from the heavier rainfall of May to August, owing to the slow movement in the sand, has accumulated and raised the water table in the sands above normal, and the maximum seepage does not reach the streams and lakes till this time.

The water in many of these lakes is strongly alkaline. This lack of drainage in the sand hills very much increases their value. It furnishes abundance of water in shallow wells where lakes are not available for watering stock. In many of these valleys water is near enough to the surface so grass roots can reach it, and here the heavy crops of hay are produced which are an absolute necessity to the stock business.

IRRIGATION.

While there are a good many small ditches in the state, the acreage under irrigation is very small. Many of these enterprises have been unsuccessful for one cause or another. East of about the 100th meridian only a few efforts have been made and these have mostly been unsatis-

factory for irrigation is usually not required. West of this line irrigation is needed in the majority of seasons, but systems are not yet well developed. Irrigation is now developing rapidly, especially along the North Platte where the Reclamation Service is constructing an extensive system. Many thousands of acres are now watered in this and other valleys and many thousands more will be, yet the water supply is insufficient to ever irrigate more than a small portion of the arable land.

At present there are numerous small tracts watered along the White, Upper Niobrara, North Platte, South Platte, and Republican rivers and the Pumpkinseed, Lodgepole, Frenchmen and Hat creeks.

WELLS.

Nearly all parts of Nebraska, especially of the older settled portions, are fortunate in having an abundance of good well water at moderate depths. The average depth of wells is probably about one hundred feet. In places along the river bluffs, in the drift region, in Frontier and neighboring counties, and on much of the high plains it is frequently necessary to go 200 feet or more for water, but there is usually no stone to penetrate so boring or drilling is an easy matter. Nearly all wells are equipped with wind pumps which raise all the water used on the majority of farms and ranches.

SOILS.

The two most important controlling factors in Nebraska agriculture are rainfall and soil. We might perhaps more properly say soil moisture and soil texture, but soil moisture is so little understood that no extended discussion of it will be attempted here. Rainfall, which has already been discussed, is usually interpreted to mean soil moisture, but there is really a wide difference between the two. Soil moisture depends not alone upon the amount of rain but upon the time of year when it falls, the rapidity of the fall, the texture of the soil, the tillage, the plant growth, the dryness of the air, the wind velocity, the temperature of the air and the soil, and perhaps other factors.

In a general way the soil areas of the state correspond to the areal geology, but each geological formation has produced several distinct types of soil. The type of soil has been affected in many places by topography and rainfall, so that in detail the characters of the soil are far from being as uniform as the geological exposures. While there are extensive areas of very uniform soil many distinct soil types occur within the state and there is a great difference between the soils of different localities. The Bureau of Soils in surveying 3,115 acres has recognized about thirty distinct soil types and a detailed survey of the state on the same scale would probably show nearly 100 different soils. The soil types covering large areas of agricultural land are not very numerous and in order to avoid the confusion arising from the use of a large number of types, the writer has aimed to discuss the soils under the more important types only, and refer to other types simply as variations of the more extensive ones.

The soil map has been made mainly from personal knowledge but personal inspection of more than 2,100 townships has been possible; therefore it has been necessary to depend upon others for details regarding many localities. All known sources of information, both published and unpublished, have been consulted. Probably over one thousand different persons have been interviewed and have furnished more or less information which has been used in the construction of the map. On a map of this scale it is not practical to go into sufficient detail to show variations of less than three miles in width, and in only a few instances, mostly along the river valleys, has any attempt been made to show smaller or narrower areas. In all cases where small areas of distinctly different soils occur in more or less alternating patches, the map shows what seems to be the dominant or prevailing type. No great accuracy is claimed for this map and a detailed survey would doubtless show many errors. Yet it is believed to be sufficiently accurate to give a more definite idea of the soils prevailing in any locality than anything that has heretofore been published, and to serve a useful purpose till something better can be produced. (Chart No. 8.)

For the purpose of discussion the soils of the state will be grouped in a general way as follows:

Soils formed from Loess.

Soils formed from Glacial Drift.

Soils formed from sandstones.

Soils formed from limestones and associated strata.

Soils formed from river deposits (alluvium).

Soils of the High Plains.

Pierre clay (gumbo).

Bad Lands.

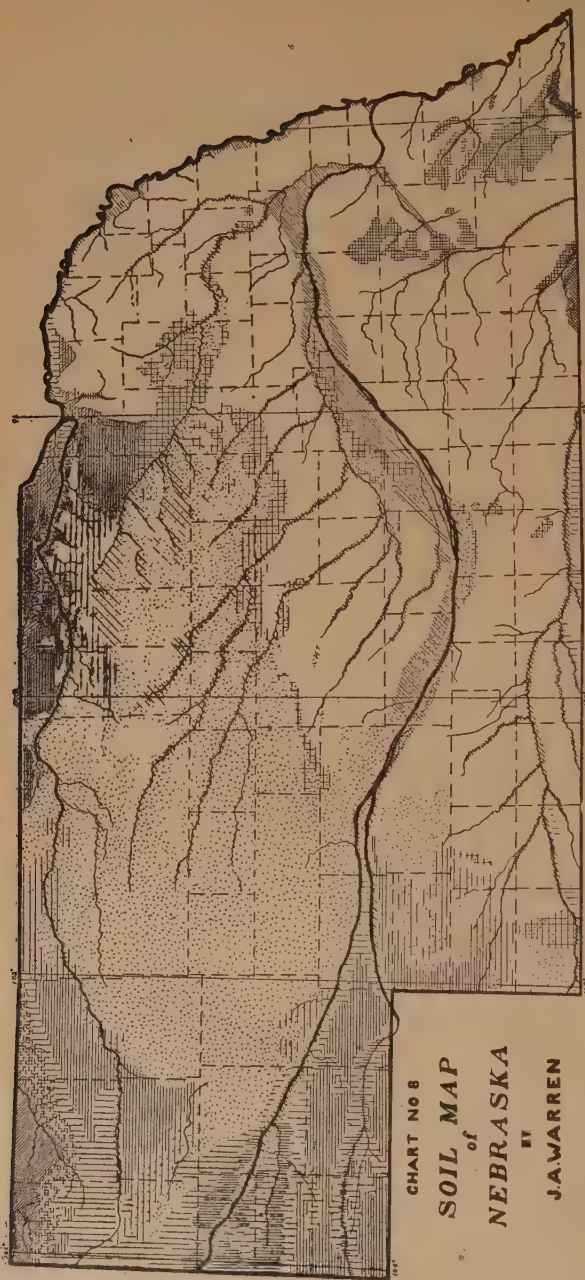
Sand hills.

Stony, gravelly and rough lands.

Soils of loessial origin (legend No. 1) cover most of the southeast half of Nebraska, an area including about 38,000 square miles and producing probably at least 80 per cent of the grain and hogs of the state. Included within this general area are several thousand square miles of river valleys, some small areas of drift soil, and a few inconsiderable patches of soil formed by the decomposition of sandstones and limestones. The Loess soils probably cover at least 30,000 square miles.

These soils are extremely uniform in character for such large areas, are richly stocked with all the mineral elements of plant food, especially potash, and well provided with humus and nitrogen. An abundance of lime is usually present.

The subsoil differs in no essential particular from the soil, except that it contains less humus and more lime, and instead of having the dark brown or black color of the soil is buff or yellow. From 10 to 30 inches deep the subsoil often contains slightly more clay than the soil due to the filtering down of the finer particles from above. Below three



- 1 Marshall silt loam derived from loess
2 Marshall loam derived from glacial drift
3 Wabash silt loam, river bottoms
4 River terraces, derived mostly from loess
5 Sandy valleys, soil sand to sandy loam
- 6 Transition from loess to dune sand
7 Black clay to sandy loam
8 Pierre clay sand and drift mixed
9 Sandy loam and sand ridges
10 Transition from loess and drift to High Plains
11 High plains. Sandy loam and sand ridges
12 High plains. Fine sandy loam mostly fertile
- 13 Terraces, Mostly fine sandy loam
14 Pierre clay gumbo
15 Bad lands area
16 Sandy, gravelly or rough, mostly unillable
17 Sand hills
- 18 Lancaster fine sandy loam
19 Black to yellowish clay loam, formed from limestone

LEGEND

or four feet there is often little or no change for 50 or 100 feet and sometimes more.

Nearly all the soils of this area are classed by the soils specialist as silt loams and fine sandy loams. The most common type is known as Marshall silt loam. This soil commonly contains 50 to 70 per cent of silt, 8 to 25 per cent of clay, 5 to 25 per cent of fine sand, and 2 to 4 per cent of organic matter. There is no gravel and never a stone. These characteristics make the loess porous enough to absorb water readily, while at the same time the particles are small enough to give the soil a good water holding capacity, but not fine enough to cause it to puddle badly or to form hardpan. On these soils there is ordinarily nothing to prevent plant roots from going to any depth.

On some of the level areas where water courses are not well defined, water sometimes stands in small ponds or intermittent lakes locally called "lagoons." From the surrounding higher lands some of the finer particles of soil are washed into these pools together with more or less mineral matter in solution. This causes the soil in these low places to be considerably heavier than that of the uplands in general and harder to work. Many of these areas cannot be farmed till drained, but when drained they make valuable farm land.

There are also small patches, rarely exceeding one or two acres in extent, where the soil is so heavy as to be very difficult to work. These patches occur more commonly on slopes where the surface soil and the humus have been washed away. Such patches are especially prominent in the vicinities of Johnson, Nemaha county, and Dunbar, Otoe county. The heavy character would indicate that these spots were composed mainly of clay, but analyses do not show very high percentages of either clay or alkali. The area of this kind of soil is very small and in most localities its chief importance lies in the trouble which these patches make in working the fields in which they occur. The Experiment Station has obtained very beneficial results from the application of 1 to 2 tons of ground limestone to the acre. Heavy applications of course manure are very helpful. Alfalfa, clover, and especially sweet clover do much towards loosening these heavy soils.

Where watercourses have cut their way through these soils, much of the finer material, and especially of the humus, has been carried away and deposited along the streams. This loess soil worked over in this way, sometimes mixed more or less with other material, and deposited in the valleys is more fertile than the uplands and slightly heavier in texture. Accordingly it has been given a different name, Wabash silt loam (legend No. 3) under which it will be discussed later.

The Marshall silt loam is excellently adapted to the growing of all crops common to the region and the limitations of production are mainly climatic. Corn, winter wheat, oats, and alfalfa thrive on all these lands, and clover and timothy in all the eastern counties. Their production is limited on the west by rainfall. It is doubtful if there is another such large area of soil in any state in the Union which is capable of producing

such satisfactory results with such a wide variety of crops as the Marshall silt loam of Nebraska. It is this soil that has made Nebraska a great producer of corn, winter wheat, oats, alfalfa, and hogs, and a great agricultural state. Residents of Nebraska should not fail to appreciate the wonderful possibilities which this soil offers to them.

In the eastern part of the state along the Missouri river, especially in Washington, Douglas, Sarpy, and Cass counties, the land is quite rolling, and the surface soil, together with much of the humus, has been removed by erosion, thus changing slightly the color and texture and leaving a slightly, heavier, stickier, lighter colored soil of somewhat different crop adaptations. On this account this soil, while only slightly different in appearance from the Marshall silt loam, has been termed the Miami silt loam. The Bureau of Soils in surveying Sarpy county recognized 69,696 acres of this type, nearly half of the county. The Miami silt loam is only a variation of the Marshall silt loam from which it has been derived. For this reason and because of its indefinite limits and the irregular tracts in which it occurs, it has not seemed best to try to designate these areas on the map.

Similar variations are found in other localities, especially in Boone, Custer, Frontier, and Lincoln counties and other rolling sections. In some places the subsoil contains more sand than the soil and in some places more clay, so the derived type may be either heavier or lighter than the soil of the uneroded areas.

Within the Loess Region there are also a number of small areas of sand, such as occur south of the Platte river near Kearney, west of Columbus, north of Grand Island and at other places. Most of these sands seem to have been brought down from the sand hills by the streams and blown out of their channels.

In many places around the borders the Marshall silt loam grades insensibly into the adjoining type. This is especially true on the west. A detailed survey would doubtless make it necessary to classify considerable areas along the western limit of the loess as sandy loam which are here mapped as silt loam. In most cases, however, this distinction is not a very important one. These lighter soils are generally better adapted to corn, potatoes and rye than to wheat.

In some places a few inches to a few feet of Marshall silt loam overlies some other type where only a thin layer of loess was deposited or where most of it has been removed. In the vicinity of the sand hills considerable areas are found where a few inches or a few feet of sand have been blown onto the loess. Where the sand is not too deep this makes an excellent corn soil. The loose, coarse surface admits the water rapidly but forms a natural blanket through which evaporation is very slow, while the silt below forms a good reservoir in easy reach of roots; therefore these soils are extremely drouth-resistant. Such areas occur in Antelope, Pierce, Boone, and other counties.

In some places in this region of transition from loess to sand hills there are hills of fine sand and clay mixed with very little silt. Some of

these hills are quite sticky, as may be seen east of Ewing in Holt and Antelope counties. In other places the hills are sandy and the valleys and level lands typical silt loam. These variations are produced largely but not entirely by the encroachment of the drifting sands upon the heavier soils. Some of the mixing, no doubt, was done while the loess was being deposited. So far as possible these transition lands, which grade on the one side into silt loam and on the other into dune sand, are indicated on the map (legend No. 6).

These areas are generally gently rolling to heavily rolling, and the form of the hills is suggestive of wind action. The soils are silt loam, sandy loam, clayey sand, or fine sand. They are largely but not all tillable. The heavier areas are well adapted to corn, potatoes, and alfalfa, but the sandier tracts are fit only for grazing and grade into typical sand dunes.

In the northern part of the state the loess thins out and disappears towards the west in northern Antelope, western Knox, and eastern Holt counties. The drift disappears almost simultaneously with the loess, but extends considerably beyond it in Keya Paha county. The Arikaree or western deposit thins out towards the east in the same region (legend No. 8). This mixing of geological formations gives a peculiarly spotted country, mostly covered by a fertile sandy loam soil which in places gives way to sand and in other places, mostly along the creek banks, to gumbo. In some places the subsoil is fine loess making very valuable land, but where the soil is underlain by gravel or coarse sand, as is often the case, the crops are very subject to injury from drouth.

SOILS DERIVED FROM GLACIAL DRIFT.

In many of the eastern counties, especially Butler, Saunders, Lancaster, Johnson, Pawnee, Otoe, and western Richardson, there are numerous irregular areas from which the loess, if ever deposited, has been washed away, exposing the glacial drift. The soil formed from the drift is mostly classified as Marshall loam (legend No. 2). Most of these areas are too small and too irregular to be indicated on the map, but the larger tracts have been designated. Johnson and Pawnee counties probably have more of this type than of any other. The Bureau of Soils found 96,576 acres of Marshall loam in surveying Lancaster county. Small areas also appear in many places north of the Platte river from Boyd county east, but the total area within the state probably does not much exceed 2,000 square miles.

These glacial deposits, as previously stated, are made up of bowlders, gravel, sand, silt, and clay, arranged in beds in no conceivable order or indiscriminately mixed. In many places, also, the loess from above has been washed down the slopes and mixed with the drift. Most of the soils formed are rich, dark loam or sandy loam, but many patches of heavy clay are also found, although these are generally not extensive. Areas of sand and gravel also occur. The Marshall loam can usually be recognized by the sand, gravel, or occasional bowlders which it contains.

In places, Marshall loam is strewn with so many bowlders that it cannot be farmed till they have been removed, but most of it is good agricultural land, although not equal to the Marshall silt loam. The topography of the Marshall loam is generally much less favorable to cultivation than that of the Marshall silt loam. It also washes much more readily and the prevention of gullies often becomes a serious problem on these soils. The Marshall loam is relatively better adapted to corn and grass than to small grain. It is well adapted to the production of many kinds of forest trees and to orcharding. Apple orcharding is constantly assuming greater importance on this soil, and with the better methods of caring for orchards and fruit which are now being adopted, it is probable that fruit growing will become one of the most important industries.

While it is generally supposed that Marshall loam and Marshall silt loam contain approximately the same proportions of mineral elements of plant food, the Marshall loam is particularly liable to be deficient in humus, and the Nebraska Experiment Station has recently found that the surface down to 24 inches is very commonly deficient in lime and gives a slight acid reaction, while the subsoil nearly always has an abundance of this material. The deficiency in lime, no doubt, largely explains the difficulty which farmers are having in starting alfalfa on this soil. Most of the Marshall loam should be either inoculated or manured before seeding to alfalfa.

Farmers on this soil should give especial attention to keeping up the supply of humus and nitrogen. The use of manure and a rotation in which clover or alfalfa occupies the land every few years is more essential than on the Marshall silt loam. When well cared for there seems to be no reason why the Marshall loam should not give as good results as the Marshall silt loam, at least for corn and forage crops, but on account of its topography and other characteristics mentioned, more care is necessary to maintain productiveness. As generally managed, this soil produces smaller yields of all crops, and as a result land values are considerably below those on the Marshall silt loam.

SOILS FORMED FROM SANDSTONES.

In several of the eastern and northeastern counties there are small outcrops of Dakota sandstone, most of which occur in ravines. Such tracts are seen in the vicinity of Lincoln and some larger areas near Thompson and Steel City in southern Jefferson county (legend No. 16). Small patches are found in several other counties. Probably the total area does not exceed fifty square miles.

The soil formed by the breaking down of the Dakota sandstone is nearly all a fine sandy loam, very light to dark brown in color and of no great depth. The subsoil is mostly yellow or gray fine sandy loam. This soil is generally poorly supplied with plant food, especially nitrogen, and is quite deficient in humus. Its water holding capacity is low, and therefore crops are very subject to injury from drouth. This is one of the poorest types of soils in eastern Nebraska but fortunately the area is limited.

SOILS FORMED FROM LIMESTONE AND ASSOCIATED STRATA.

In nearly all the counties bordering the Missouri river and in Lancaster, Johnson, Pawnee, Gage, Jefferson and several other counties there are small areas of residual soil formed by decomposition of the underlying limestone and associated strata of clay and shale. The areas of this soil are not sufficiently large to appear on the map except in southern Jefferson and Thayer counties, southwestern Richardson and a small tract in Nemaha (legend No. 17). This soil is generally a black to yellowish brown clay loam, quite productive, if properly tilled, but is often deficient in humus. It is harder to work than most of the soils of eastern Nebraska. It is often not of sufficient depth to give the best results with grain crops. It is better adapted to clover and wheat than to corn and is well suited to fruit. Most of the soils in the areas mapped have not been derived entirely from limestones and clays but are more or less mixed with material from the drift and loess.

ALLUVIAL SOILS.

Along nearly all the water courses are strips of soil that has been deposited by the streams, varying in width from a few feet to more than fifteen miles in some places along the Platte river. The characters of this soil are very variable depending largely upon the surrounding uplands. In many instances, however, the soil has not been derived from the uplands in the immediate vicinity, but has been brought down by the streams from far to the west or northwest. In the eastern part of the state the soil of the river bottoms has mostly been derived from the loess and drift at no great distance, and is made up largely of the finer particles of soil washed from the surface of the uplands. These soils are made up of many and variable layers. Layers of clay and fine sand often alternate.

Most of this soil is a rather heavy, black silt loam, very rich in all the elements of plant food and containing an abundance of humus. It has been named the Wabash silt loam by the Bureau of Soils who found 18,496 acres in Sarpy county, 87,616 acres in Lancaster, and 25,152 acres in the Stanton area (legend No. 3). Wabash silt loam does not usually differ greatly in its physical analysis from Marshall silt loam but contains considerably more humus. On account of its location much of this soil is subject to overflow in times of high water, and in some places the slope is not sufficient to give good drainage. This is the richest soil of the state, and, where well drained, produces the largest crops of corn and hay, and is fairly well adapted to small grain and potatoes. Where drainage and elevation are favorable this is the most valuable land in the region.

On the terraces of the Platte valley, especially between Grand Island and Gothenburg, and along the Loups and the Republican and its tributaries, is a soil in many respects resembling the Marshall silt loam and the Wabash silt loam, but sometimes more sandy. This soil is included

here because the terraces are usually spoken of as part of the valleys, and are generally known as second bottoms. This is one of the very best soils of the state and is well adapted to all the crops common to the region. It is usually well drained and very productive. It is more productive than the uplands and accordingly is valued much higher. It is on these terraces that most of the alfalfa of the Platte and Republican valleys is grown.

The bottom lands of the Republican and Niobrara valleys and of the upper parts of the Platte, Elkhorn and Loup valleys are mostly sand and sandy loam. There are also considerable areas of sandy soil in the Platte valley through its course across the state. These soils are for the most part quite fertile and productive, wherever there is sufficient water supply, but in many instances they are underlaid by loose sandy subsoils which have little water holding capacity, and hence are especially liable to suffer from drouth.

In western Nebraska there are considerable areas of second bottom, or terrace land, along the Lodge Pole and Pumpkin Seed creeks and the North Platte river (legend No. 4). These soils are derived mostly from the Brule clay and the Ogallala and Arikaree formations through which these streams have cut their channels. These formations are all more or less sandy, and as a result the soils formed from them are mostly sandy loams, with some areas of sand. The soils of these terraces are, for the most part, deep, fertile and easily tilled. They are very valuable where irrigation has been established, being capable of producing large yields of all the crops suited to the climate. They seem especially well adapted to alfalfa, sugar beets, oats, and potatoes.

SOILS OF THE HIGH PLAINS.

In Chase, Perkins, and a number of other western counties and in the northern parts of Cherry, Brown, Rock, and Holt there are considerable areas where sand ridges and loamy level lands alternate in such a manner that it is impossible to separate them on this map; therefore, they have been indicated simply as mixed land only a part of which is tillable (legend No. 9). The soils of these areas, aside from the sand ridges, are mostly sandy loams, ten to twenty inches deep, underlaid with subsoil made up mostly of fine sand and a small percentage of clay. On account of the loose surface, water is absorbed quickly by these soils, and penetrates them deeply, but evaporation from them is slow; hence they are the most drouth resistant soils of the region. They are in the main too sandy for the best results with small grain but are better suited to the production of corn, sorghum and potatoes.

Of the western part of the state, the type of soil best adapted to general farming is found on the level tables of Deuel, Cheyenne, Box Butte, Sheridan and other counties (legend No. 10). This land is termed by the settlers "hard land" in distinction from the sandier soils. It is mostly fine sandy loam, six to twenty-four inches in depth, underlaid with a deep subsoil which sometimes contains a little more clay than

the soil, but often is more sandy. In some places these soils are underlaid by beds of soft limestone called native lime, magnesia, etc. Where limestone is too near the surface, crops are almost certain to suffer from drouth, and for that reason, if for no other, much of this land should not be broken.

These soils of the level tables are well supplied with all mineral elements of plant food but are deficient in humus. They are, however, capable of producing heavy crops of grain when the rainfall is sufficient. The most important question here is not fertility but moisture. While much of this land has been settled for upwards of twenty years, for the most part, only shiftless methods of tillage have been employed. The conservation of moisture is of prime importance and therefore, the best of tillage is a necessity.

These soils are well adapted to all the grain crops and to potatoes and alfalfa where water is to be had. Potatoes have come to be the most important dry land crop in Box Butte, Sheridan and Dawes counties. While the yield of tubers is usually small, on account of the light rainfall, the quality is excellent and the crop is produced with a minimum of labor.

Within the High Plains are some small unimportant areas of soils that would rank as clay or clay loam.

PIERRE, CLAY OR GUMBO.

In the northern parts of Sioux, Dawes and Sheridan is a considerable area generally known as the Bad Lands. In the northern part of this area the Tertiary formations have been removed by erosion and the Pierre shale is exposed. This has decomposed into a heavy brown or black clay known as gumbo (legend No. 12). While this soil is rich in plant food and produces a good growth of grass, where sufficiently moist, it is extremely difficult to cultivate and frequently contains damaging amounts of alkali. In this area, too, it is frequently impossible to get good water for domestic use and for stock. This makes it difficult to use these lands even for ranching.

In the northern part of Cedar, and Holt counties, northern and western Knox, northwestern Antelope, most of Boyd and parts of Keya Paha and Cherry, the soils have been derived from Pierre shale mixed in various places with drift, Loess, Niobrara chalk and Tertiary materials so intermingled that it is impossible to show these areas separately on the map, so they have been grouped together (legend No. 7).

The soils of these areas vary from sandy loam through silt loam to heavy clay. They are mostly fertile and where not too hilly, are quite highly valued for general farming purposes, but they are generally hard to till. On account of the heavily rolling to rough topography and the formations underlying them, there is frequently much difficulty in securing good wells. In most of this region, however, artesian water can be reached but on account of the depth the cost of artesian wells is too great to warrant their use on the average farm.

BAD LANDS.

In the northwest corner of the state the next exposures above and to the south of the Pierre clay are deposits of light colored sand and clay which erode very rapidly. On account of the rapid erosion considerable areas are devoid of vegetation. These are the Bad Lands proper (legend No. 13).

The soils formed from these deposits, where the topography is sufficiently smooth to prevent erosion, support a fairly good growth of grass, and where irrigated prove to be very fertile and valuable. Only a part of the bad lands area as shown on the map is typical bad lands. Within the area are many valleys of excellent soil which has been derived partly from the Brule clay and partly from the formations above it. There is also a very small area of bad lands at the foot of Scott's Bluff in Scott's Bluff county.

SAND HILLS.

Most of the soils of the sand hill areas shown on the map consist almost entirely of fine sand (legend No. 15). These sands, while usually grassed over, are deficient in all or nearly all the elements of plant food, and especially in nitrogen and humus. Wherever vegetation is destroyed, the sands are almost sure to drift; for this reason they cannot be cultivated but must be utilized as pasture and hay land. The amount of land required to pasture one animal varies according to the amount of valley, but ranges from five to forty acres with an average of ten to twenty acres.

Within the sand hill areas are many valleys and limited areas of table land where the soil is sandy loam. These soils are fertile and produce good crops of corn, potatoes, clover, timothy and alfalfa. In many instances, however, these tillable lands are too far from market to be utilized for anything which cannot be fed upon the ranch.

Within the Sand Hill Region are many wet valleys, that is, valleys in which the ground water is near enough to the surface to be within the reach of plant roots. These valleys are mostly devoted to the production of wild hay but some of them are utilized for other crops. The hills produce little winter feed for stock, except on the heavier lands and remnants of the old high plain where buffalo and grama grass form a considerable portion of the herbage, and therefore it is necessary to depend upon the valleys for dry forage. Since this is the case, the greatest need of the ranchman in this region is not crops for sale but for forage, and the majority of ranchmen control enough hay valleys to produce sufficient feed to winter the stock.

In the borders of the sand hill region and near the heads of some of the streams, especially in Brown, Rock, Holt and Wheeler counties, are low lying tracts of sandy lands varying from almost pure sands to rich, dark silt loams (legend No. 5), frequently underlaid with water at no great depth. Where too wet or too sandy for cultivation, these soils produce good crops of native hay, but the heavier soils are being utilized for the production of all the common farm crops, and give especially

good results with alfalfa and potatoes. These tracts differ but little from the better valleys in the hills.

STONY, GRAVELLY AND ROUGH LANDS.

In the eastern part of the state along some of the streams, are narrow strips of land too rough for tillage. There are also considerable areas along the Republican river, along the Niobrara, and in all the western counties (legend No. 14). The soils of these rough lands vary decidedly according to the geological formations through which the water courses are cut. In some places they are mostly clay, in others sand, and again precipitous buttes of soft stone. These rough lands are adapted only to grazing, and therefore a discussion of the soils would be of little value. Under this head is included a considerable amount of rolling sandy and gravelly land, especially in Sioux county, which, if under favorable climatic conditions, might be farmed but is here adapted only to grazing.

GRAIN CROPS.

Besides the factors mentioned in the introduction as limiting the distribution and production of crops, there are many indirect influences which are often fully as important. The production of one crop is often controlled by the success of some other crop or some kind of stock, that is, by its relative success. It is not enough that a crop be profitable. It must be more profitable than other crops in order to obtain prominence. The most profitable crop is the one that will be produced. This is often determined by the success of some particular kind of stock. The relations, then, between different crops and between crops and stock, and the way these crops fit into the system of farm management, are important questions.

Sometimes the availability of labor is a determining factor and again it is the distribution of labor. A crop may be profitable if it can be cared for when labor would not be otherwise employed, but the same crop might not be able to compete with other crops if it required attention at the same time. For these reasons, it is necessary that each crop be considered in its relation to other crops and to stock.

CORN.

Since the advance guard of agriculture first crossed the Missouri river, Nebraska's fertile prairies were recognized as an excellent corn country. Corn at once became the dominant crop and still maintains that position by all odds. Its cultivation increased almost as rapidly as land could be broken. Producing corn for the market became the occupation of the Nebraska farmer. On a large proportion of the farms only a small part of the crop was fed to stock; there was not stock to eat it. Each year more corn is fed on the farms, especially as the acreage of alfalfa increases, and now only a small part of the entire crop is shipped out of the state; probably about half of it is fed to hogs alone.

In spite of the increase acreage in small grains, alfalfa, and tame

grasses, corn still occupies more land than all other grains combined. On valley, hill and dale, on heavy soil and light, the state over, excepting in a few localities, corn stands first and foremost. In 1897 Nebraska took first rank among the states as a corn producer. This proud distinction was not, however, to be retained, but the average crop since that time shows Nebraska to be the third corn state, giving place only to Illinois and Iowa, and producing more than one-thirteenth of the total corn crop of the country. The annual crop now amounts to over 175,000,000 bushels.

The average yield of corn in the state for the forty years ending in 1907 was a trifle over thirty bushels per acre, and has varied from six bushels in the drouth year of 1894 to forty-two bushels in 1869 and 1878. By decades the yields have been 32.7, 33.8, 26.7 and 27.1 bushels, respectively. The decrease in yield per acre in the last two decades has been marked. The shortage in 1888 to 1897 was partly due to the unusual number of dry seasons during that period. But that is not true of the last ten years. There are at least three factors evident which seem to have been responsible for these lower yields. First, until about twenty years ago nearly all the cultivated land was in the east half of the state, which is by far the best adapted to the production of corn. Since that time large areas farther west have been brought into cultivation. The western half of the state gets much less rain than the eastern, and, therefore, a much lower average yield of corn, thus reducing the state average.

Second, much of the farm land has now been devoted to crops for from thirty to forty years consecutively, and some fields have grown corn for twenty years or more without a change. At least a large portion of this land has never been fertilized in any way, or rotated with grass or any leguminous crop. This continuous drain has told upon the native fertility and upon the yields. There is no statistical evidence to prove this point but it is a matter of common observation that land which has been cultivated only a few years is out-yielding older fields. It is also a matter of common observation that where corn follows clover or alfalfa, the yields are greatly increased.

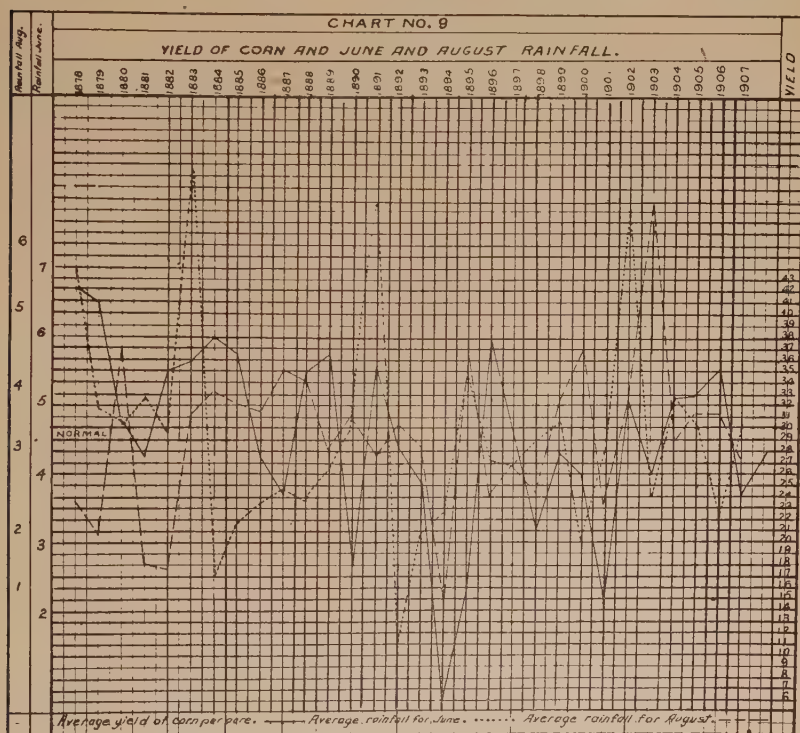
Third, root worms and root lice have increased rapidly the last few years and have greatly reduced the yields of many fields. The decrease in yields is the more significant when we remember that it has occurred in spite of the great improvement in cultivation, and the very decided improvement in varieties and in the selection of seed.

*Effects of the Distribution of Rainfall on the Yield.**

With the possible exception of tillage, the time of rainfall is the most important factor controlling the yield of corn. It has long been recognized that seasonal rainfall, that is rainfall from April to August inclusive, is more important than that of the other months, but charts Nos.

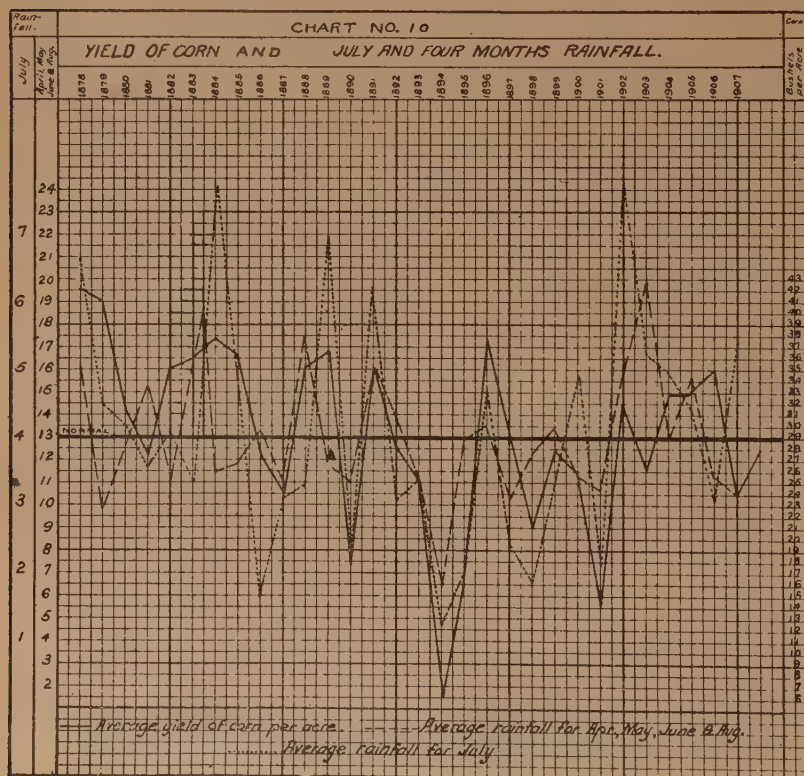
* For a more extended discussion of this topic see paper by the writer in Rept. of the Coop. Expt. Assn. of Great Plains Area, 1908, also paper by J. W. Smith in Year-book of U. S. Dept. of Agr., 1899, and Bul. 85, U. S. Weather Bu. by H. C. Dunwoody.

9 and 10 show that rainfall for July alone almost determines the crop, and that the variation in the rainfall of other months has had little effect. The examination of the charts shows that the corn yield has varied widely from the July rainfall only a few times, and reference to the reports of the Climatic and Crop Service of the United States Weather Bureau for those years shows that in nearly every instance when an average crop has followed a low July rainfall the temperature and wind velocity for that month were low or the rain very favorably distributed, and that when low yields have followed heavy or normal July



precipitation the distribution was unfavorable or the temperature and wind velocity high. In other words, when the corn yield has not followed the July rainfall it has followed the moisture condition of the soil for that month, except when early frosts cut the crop short. This does not mean that May and June rains are of no value to corn, but that July is the critical month. Until about the time corn is laid by it requires but little water, and so far it seems that conditions early in the season have never been so adverse that favorable weather in July could not produce a good crop. It is a common observation that "we always have a good crop the Fourth of July."

Up to about July 1 the leaf surface is small and the ground is thoroughly tilled, thus keeping evaporation at a minimum. Then all is changed, cultivation ceases, the leaf surface becomes larger, the plants tassel and form ears and make their largest demands for water. It has been calculated that the total leaf surface of a field of well grown corn is about six times the area of the land.* From every square inch of these leaves water is rapidly evaporated. It is seldom that unfavorable con-



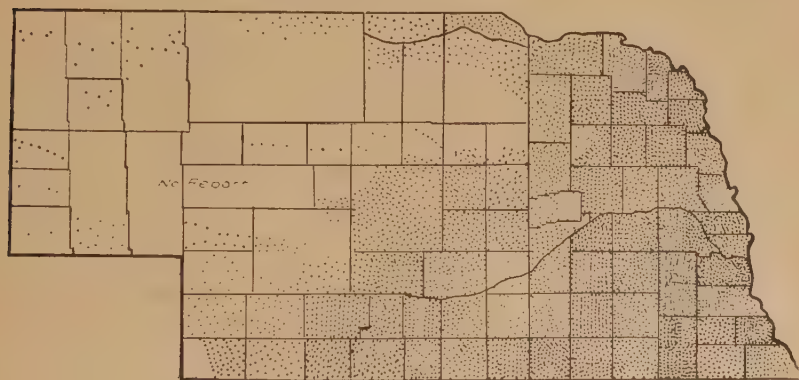
ditions in July can be overcome by favorable conditions earlier or later in the season. This is possible only when there are good rains the last of June, no great deficiency in July and good rains early in August. These conditions, especially if accompanied by low temperature and low wind velocity in July, may compensate for a deficiency of an inch or a little more in the precipitation of that month. Only once, 1887, has a normal crop been secured when the July rainfall was deficient by as much as 1.1 inches.

* T. F. Hunt, "Cereals in America,"

Geographical Distribution of Corn.

Not only is corn the most important crop of the state, but it is the most important crop of most counties in the state. In some counties nearly half of the total area of the county is planted to corn. The chart shows a strikingly uneven distribution of corn over the state, which is due mainly to variations in climate, soil and topography. In many counties the heavily rolling topography is an important limiting factor, for corn succeeds better than small grains on such land. This is shown by the relatively large areas of corn in Sarpy, Thurston, Dixon and other counties. Corn is better adapted also to drift soils than small grains are. This taken together with the topography is brought out strikingly by the very large acreage of corn in Johnson, Pawnee and Lancaster counties. Its advantage over small grains for very sandy land is shown by referring to Chase, Dundy, Logan and Loup counties. On the

CHART NO. 11.



Corn. = 1000 A.

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level loess prairies of Phelps, Adams, Clay and some other counties, the area devoted to this crop has considerably decreased the last few years because of the great success of winter wheat.

A comparison of chart No. 11 with the rainfall chart shows that on crossing the line of twenty inches average annual precipitation the acreage of corn decreases very rapidly. North of the Platte river the sand hills cross this line and become the limiting factor.

The adaptability of varieties is determined almost entirely by rainfall and length of growing season. In the western and northwestern counties, both the short season and the low rainfall make early varieties a necessity. In the southeastern counties fairly large, late varieties, though not the largest, can be grown. Goig north and west progressively earlier varieties must be used until the northwest counties are reached, where only the very earliest are possible. An examination of the frost charts

shows that the difference in length of season between the southeast and the northwest portions of the state is at least a month, and, in fact, the difference is more than this because of the lower temperatures caused by the high altitudes of the northwest. The season is approximately one day shorter for each hundred feet increase in altitude and also one day shorter for each fifteen miles farther north. This must be taken into consideration in moving seed from one locality to another, and in selecting varieties.

Dent corns are grown exclusively except in the northwest. In nearly all parts yellow varieties predominate, but in some localities white corn is favored, while red and calico are used to a very limited extent. No variety is adapted to all parts of the state. A much larger, later corn is suited to the southeast than to the northwest.

In the eastern counties some of the best varieties are:

Yellow: Hogue's Yellow Dent, Ried's Yellow Dent, and Golden Beauty.

White: Boone County White, Nebraska White Prize.

In the central counties Ried's Yellow Dent is the most popular. In the extreme-western and northwestern counties earlier varieties are required. Pride of the North, Minnesota Pride, and White Cap are among the best. Squaw and Flint are also used. It is quite probable that Australian White (flint) would be one of the most reliable varieties for Cheyenne, Kimball, and the counties farther north, although in the best seasons it might not give as large yields.

WHEAT.

Nebraska now stands fourth among the states as a wheat producer, being exceeded only by Kansas, North Dakota and Minnesota. In winter wheat she is surpassed by Kansas only.

Wheat is the second grain crop of the state, both in acreage and in value. While it has always been one of the first three crops, it has been much more prominent the last eight years, but still its acreage is only about one-third that of corn. In the early history of the state winter varieties were tried but were not successful because the varieties were not sufficiently hardy to withstand the winters. Spring varieties were grown almost exclusively for many years, but over much of the territory spring wheat was never a satisfactory crop, and in many of the southern counties its growth had been practically abandoned several years before hardy winter wheat was secured.

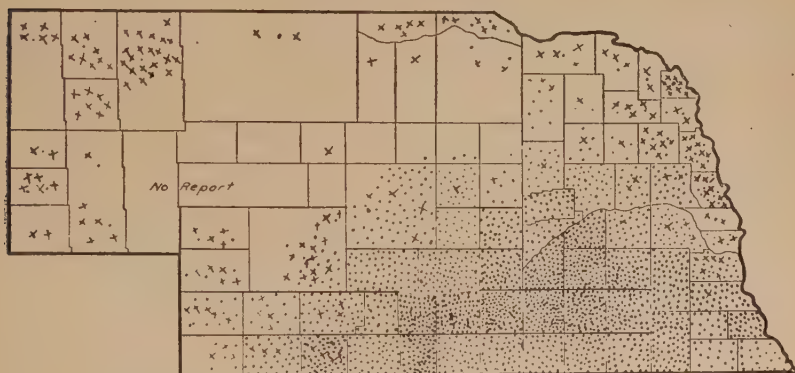
In the early 80's Turkey Red winter wheat was introduced from Kansas. This variety proved hardy and was soon widely distributed over the southeastern counties. It was a profitable crop from the first, much more profitable than spring wheat ever had been. It increased rapidly in favor and worked its way north and west till now it is grown to some extent in every farming county, and has almost entirely displaced spring wheat in all the south half of the state, except in the western counties where macaroni is grown. It reaches its greatest development on the

level prairies of the south central counties. On the very ground where spring wheat had previously been abandoned the acreage of winter wheat now exceeds that of corn.

On account of the larger yields generally secured from winter wheat it is constantly growing in favor in the north and west and may soon drive spring varieties out of the northeastern part of the state, and dispute the ground with durum in the western. In 1908 there were but 203,102 acres of spring wheat, while 2,342,508 acres of winter wheat were grown. In most parts of the state, Turkey Red produces once and a half to twice as much to the acre as spring varieties.

No other variety has been able to stand against the Turkey Red, but recently Karkov, another Russian wheat of the same type, has been introduced by the State Experiment Station and the United States Department of Agriculture, and is proving slightly superior.

CHART No. 12.



Winter wheat. = 1,000 A.
 Spring wheat X = 1,000 A.
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Chart No. 12 shows that winter wheat is almost confined to the south half of the state. This may be largely due to the fact that it came into the state from the south and has not had time enough to become popular farther north. There are, however, certain other influences that can not be overlooked. Spring wheats have given better satisfaction in the north than in the south, and oats are a more profitable crop. The harvest of spring grain does not interfere with corn cultivation as does that of winter wheat. The straw, too, is valuable for feed while winter wheat straw is almost useless except for bedding. The western limit of wheat is fixed by rainfall, although it is one of the very best dry land crops known.

The very large amount of winter wheat grown in the south central counties is apparently due to particularly favorable climatic, topographic and soil conditions. The rainfall of these counties is twenty-four to

twenty-eight inches. The soil is rich, deep and mellow but fairly firm, with a firm subsoil; but perhaps the most important of these influences is topography. The level land seems peculiarly adapted to this crop, in fact one can almost read topography on the wheat chart. Compare, for example, the relative acreage of wheat and corn in two level counties, Clay and Adams, with that in two much rougher counties adjoining them, Nuckolls and Webster.

	Acres per Square Mile.	
	Corn.	Wheat.
Clay, (level)	159	180
Nuckolls, (rolling)	189	75
Adams, (level)	125	184
Webster, (rolling)	164	72

The comparatively small acreage of this crop in Johnson and Pawnee counties is no doubt largely due to their hills. The conditions in south central Nebraska are almost exactly those of the best wheat region of Kansas, except that these counties of Nebraska may be better adapted to corn.

Three almost distinct spring wheat areas must be recognized. The northeast, where only northern spring wheats are grown; the northwest, where both northern and macaroni are grown; and the southwest where macaroni predominates. It will be noticed, however, that only a few of the southwest counties have as many acres of macaroni as of winter wheat. Macaroni, unlike other grains, is limited on the east by rainfall, for it thrives only in dry climates. This wheat was introduced about ten years ago and on account of its drouth-resistant qualities immediately became popular in spite of the fact that it is discriminated against on the markets to the extent of five to ten cents per bushel.

Cultural methods used with winter wheat vary considerably in different parts of the state, but many of these differences are merely the differences between careful and careless work. Some of them, however, have geographic control. In the eastern counties wheat is rarely drilled in the corn field for it does not produce a satisfactory crop. Going westward this practice is met with to some extent in Clay county, and is observed to increase farther west. In Phelps county the yields secured by seeding in the corn and those from plowed land seem to be about the same, but farther west the corn ground is said to produce the best crop. This is probably due to the effect of the stalks in catching the snow and in part to the fact that the falls are dry and the plowed ground lies so loose as to dry out badly in the winter.

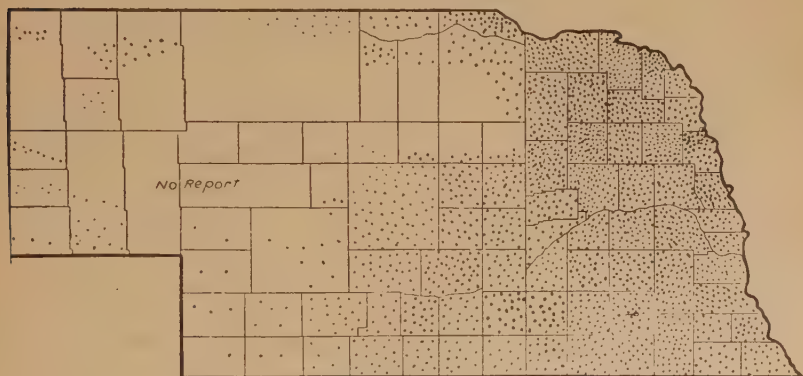
OATS.

While Nebraska stands fourth among the states in quantity of oats produced and raises over one-fifteenth of the total crop of the country, the acreage devoted to this cereal is now somewhat less than that of wheat. Oats had long been the second crop of the state in acreage, but for the last two years have been surpassed by wheat. The oat crop is

much more evenly distributed over the state than any other grain crop, although it does not assume first place in any county.

Oats are not very generally produced as a market crop except in Scott's Bluff and some of the northeast counties. In most of the state the main part of the crop is used for horse feed. In southern Nebraska farmers do not usually grow oats to make them a profitable crop, but because they are needed for horse feed and also in the rotation. "Oats don't pay, but I have to sow them to change my land," is a common expression. Except in the western counties, winter wheat drilled in the corn has not been satisfactory. This makes a spring crop a necessary medium in changing from corn to wheat. Oats meet these requirements better than any other crop. (Chart No. 13.)

CHART No. 13.



Oats . = 1,000 A.
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The geographic limitations of this crop are not so marked as those of corn and wheat. Oats do not thrive as well on sandy soils as do corn and rye, and are conspicuous by their scarcity in several counties, especially in the southwest, where barley seems to have partly displaced them. The oat shows no indication of centralization, except in the northeast counties, where the climatic and soil conditions seem to be a little more favorable, but perhaps indirect influences of other crops are more important. There is considerable tendency to localization of varieties, but varieties are changed so rapidly that the prevalence of a variety in a certain locality does not necessarily prove its special adaptability.

BARLEY.

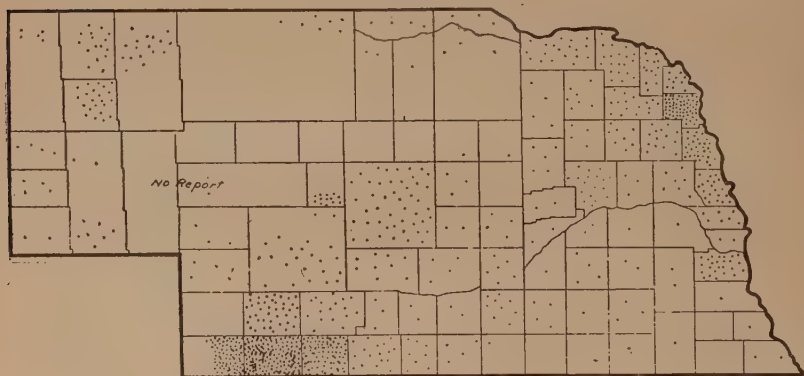
Barley is not an important crop of the state, only about 100,000 acres being grown. It is of no consequence in any of the southeastern counties, but is given more attention in the north and west. Only about one-fourth of the counties produce as much as 1,000 acres. There are,

however, a few counties where it is one of the most important crops, notably Hitchcock and Red Willow. Barley seems to be rather better adapted to sandy soils and dry climates than oats. It is also much better adapted to new ground than to old. Comparison of charts 13 and 14 shows that in every county where barley assumes any importance fewer acres of oats are grown. (Chart No. 14.)

This crop was at one time much more generally grown than at present, but it is recognized as a breeder of chinch bugs, and has not usually been as profitable as other grains.

Beardless barley seems to be gaining favor in the northwest, especially for hay. Hulless barley is now being experimented with in the west and gives promise of success.

CHART No. 14.



Barley . = 100 A.
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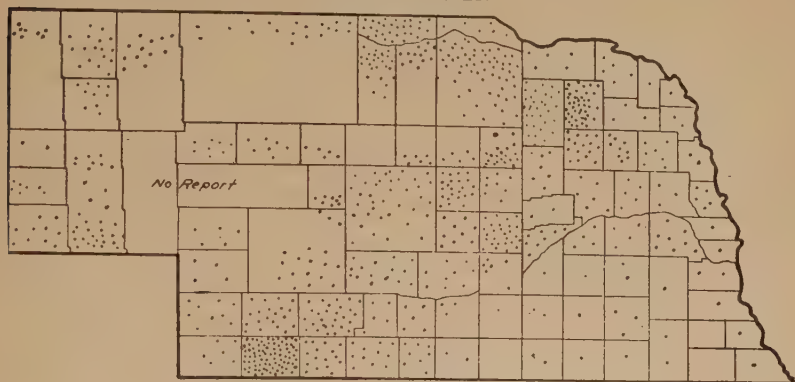
RYE.

Rye, while grown in all parts of the state, is mostly confined to small fields and is not a leading grain crop in any county, but in many localities it constitutes an important secondary forage crop, especially in the western counties. On many farms winter rye is always grown because it furnishes a large amount of pasture late in the fall and early in the spring when there is no other green feed. For this purpose it is especially useful for calves, pigs and poultry. When used in this way it is generally left to produce what grain it will. In the northwest counties spring varieties mainly are used and much of the crop is cut for hay.

Rye will produce better on sandier land than any other grain unless it is corn, and its presence in regions bordering the sand hills is very

noticeable. In the majority of winter wheat counties the acreage of rye is remarkably small. (Chart No. 15.)

CHART No. 15.



Rye = 100 A.
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EMMER.

Emmer, commonly called speltz, is a comparatively new crop. It is grown sparingly in all parts of the state, but more commonly in Holt, Custer, Keya Paha and the western counties. It is grown purely as a feed crop. For horses it gives good satisfaction as a substitute for oats. For hogs it is somewhat less valuable than barley. Its main value lies in its hardiness and especially in its ability to withstand drouth. Winter emmer has been tested several years at the North Platte station and has proved partially hardy and a heavy producer.

MISCELLANEOUS CROPS.

POTATOES.

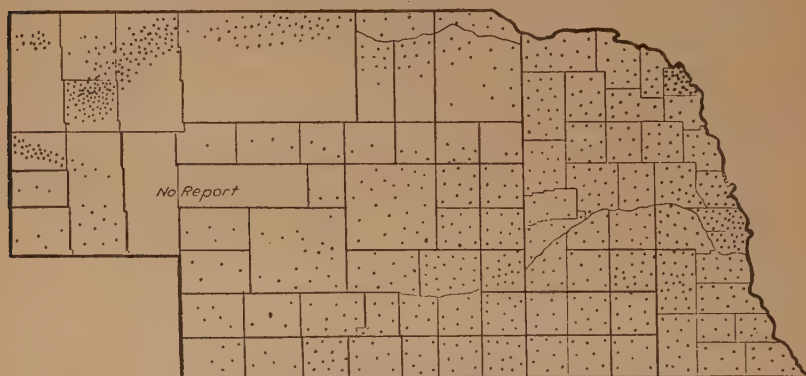
While potatoes are grown on nearly every farm in the state for home consumption, in most places they are not a general market crop, and frequently are not grown in sufficient quantities to supply the local demand. Only a few counties produce a surplus and several counties must always import. Some potatoes are shipped into the state every year and some are shipped out. On the average, production and consumption are probably about equal. Over 90 per cent. of the crop is consumed within the county producing it.

The fact that on most farms potatoes are grown for home consumption only accounts for the remarkably even distribution shown by chart No. 16. Still four distinct potato centers must be recognized: Douglas and Sarpy counties which produce potatoes for market in the city of Omaha; Dakota county, which markets its crop just across the river in Sioux City; the northwest, where potatoes are grown for export; and Scott's Bluff county, where irrigation has made the crop a success.

The acreage for 1908 is given as 100,277, and the yield at 8,531,622 bushels. This is a larger acreage than had been planted since 1900, but less than for a number of years preceding that date. The greater part of the state is not especially adapted to potato culture, yet good yields of good tubers can be produced in all sections. It is here more a question of the inclination of the farmer than of adaptability of soil and climate. There is more heavy work connected with potato culture than with the more common field crops, and most farmers wish to avoid this.

Except in the northwest, potatoes are usually of minor importance and for that reason are generally poorly tended. There are, however, scattered over the state in nearly every county, potato growers who make larger profits per acre on potatoes than is common on other crops. These facts show that potatoes intelligently handled are among our most profitable crops.

CHART No. 16.



Potatoes . = 100 A.

For the last eight years the acreage of potatoes has been much less than for the preceding decade, due in a large measure, no doubt, to the increased profitableness of grain crops and the scarcity of labor, but the rise of the potato industry in Colorado has also been an important factor.

Coincident with the decrease in the potato acreage of the state has come a rapid increase in the northwest counties, notably in parts of Holt, Rock, Brown, Cherry, Sheridan, Dawes, Sioux, Boxbutte and Scott's Bluff counties. The sandy loam soils of these counties produce a quality of tuber that can not be competed with by the product of the heavier soils of the Loess Region. The clean smooth skins, the mealy flesh and the excellent flavor of the "sand hill" tubers have won them favor everywhere. As a matter of fact, most of them are not grown in the sand hills but on the fine sandy loam of the smooth prairies.

Except in the irrigated valleys, the yield of potatoes in these counties is generally small, but the cost of production is also small. The soil is

very easily worked, weeds are not so numerous and persistent as in more humid sections and land values are much lower. Besides this, potatoes, when thoroughly tilled, are the most drouth-resistant, and therefore the surest, of all market crops.

In none but the northwestern counties do potatoes become one of the principal crops. But there they are a chief money crop. What wheat has done for the southeast, "spuds" are doing for the northwest. In Box-butte county they rank first in acreage and lead all other crops in value by a large margin. Over one-fifth of the cultivated land of the county is devoted to them. The possibilities for this crop in the northwest are limited only by the markets and the men to do the work. Hundreds of thousands of acres yet unbroken are as well adapted to the potato as any land now utilized for it. All through the Sand Hill Region are loamy valleys where potatoes produce well.

In Scott's Bluff county irrigation is responsible for the large production of potatoes. Conditions here are especially favorable to large yields of elegant tubers. It is probable that with the large acreage now being brought under irrigation and the improvement in transportation now being made, Scott's Bluff county will become one of the greatest potato centers in the United States.

Among the myriads of varieties of potatoes introduced into the state at various times, one, the Early Ohio, has steadily gained in popularity and now stands without a rival. In many markets the Early Ohio is not considered a first-class potato; it is not the best keeper, not the best shipper, not the best quality, not the smoothest, and is not white, and under favorable conditions is not the best yielder. Yet, under Nebraska conditions, for sureness of yield, keeping qualities and flavor combined, no other variety has been able to compare with it. Under irrigation some of the larger yielding white varieties, as Pearl, Rural New Yorker and Carman are preferred.

SUGAR BEETS.

Since the building of the sugar factory at Grand Island in 1890 the history of beet culture has been a thorny path. At one time it was thought by some that sugar production would sweep everything else before it, but beets have never become a popular crop. Of the three factories that started in the state, two, for one reason or another, have been closed. Beets have been grown by a few farmers in many counties besides in the vicinity of the factories at Grand Island, Ames and Norfolk, and usually good profits have been made. Some of the serious difficulties with the crop are: Labor is often hard to get; there is much heavy work; the crop is very different from any to which the farmers have been accustomed or for which they were equipped. In the irrigated valleys of the west, beets will probably become one of the most important crops as soon as factories are available. The soil and climate are well adapted to sugar production; the yields are large; and the high price of land will necessitate the production of the most remunerative crops.

SORGHUM FOR SIRUP.

Sorghum sirup has been produced in a limited way since the first settlement, but has never become an important product. Sorghum mills have mostly been small and produced sirup for local consumption only. A few large mills were operated for a number of years at Hastings, Fairfield, Trumbull and perhaps at other points, but so far as the writer knows, all have closed. Sirup and seed were often a very profitable crop, but the market for both was rather uncertain, and the cane is very much subject to injury by freezing.

BUCKWHEAT.

Buckwheat has been grown in a few scattered patches each year, but has never gained any importance in any locality. Only fair yields were secured and the crop was very uncertain. Before the introduction of alfalfa, buckwheat was grown mainly as a honey plant, but in this respect alfalfa is so far superior that there seems little need for buckwheat, and it will probably soon disappear entirely. Only about 1,000 acres were reported last year. In summer and fall the weather is too warm and dry spells are too frequent for this plant to thrive.

TRUCK.

Trucking is an undeveloped industry in Nebraska and the opportunities are large. Thus far the Nebraska farmer has scorned "truck" and preferred to give his attention to larger fields and more staple products. The high prices of land now prevailing will doubtless call more attention to various phases of trucking and other more intensive systems of management. Truck crops have never received any attention except for local consumption, and there are few towns in the state that are not obliged to import vegetables that might be easily and profitably produced in the vicinity. There is no trucking of any consequence except in the immediate vicinity of some of the larger cities. At a few points along the Republican and Platte rivers, sweet potatoes have been grown for shipment in a small way. Nebraska should grow sweet potatoes at least for her own markets. Canning factories for putting up tomatoes, sweet corn, etc., have been established at many points and a number are now doing a thriving business, among which are Peru, Nebraska City, Beatrice, Fairbury. Tomatoes are a profitable crop everywhere. It is probable that cabbage and onions will become important crops in the North Platte valley.

SEEDS.

In a few localities the production of garden seeds under contract for seed dealers has received a good deal of attention. Large quantities of cucumber, melon, squash and sweet corn seed have been grown at Albion, Richland, Waterloo, Lincoln, and other points. This industry is capable of great extension, especially in the sandy valleys of the northwest.

FRUITS.

Apples.—Most of the southeast counties have now become quite important shippers of apples. Nearly all the state can grow them, though how much of it can produce apples as a profitable commercial crop is not yet demonstrated. It is certain that apples are a very profitable crop in all the southeastern counties, but most farmers are not experienced orchardists and fruit growing does not receive the attention it deserves. Very few orchards are ever sprayed and in consequence an inferior grade of fruit is usually put on the market. That with reasonable care apples of excellent quality can be produced in all southeastern Nebraska is no longer open to question.

We have much land, especially the glaciated areas in Saline, Seward, Saunders, Lancaster, Pawnee, Johnson, Nemaha, Richardson, Otoe and Cass counties, and many of the loess hills of these counties that would probably produce more profit from apples than any other crop. These hilly lands are especially well adapted to orcharding. The soils are favorable and the excellent air drainage secured by the rough topography gives protection from frosts. Many of the poor stony hills, which a few years ago were producing scarcely enough grain to pay for cultivation, are now growing large crops of apples and have become the most profitable parts of the farms.

Grapes.—Such hardy varieties of grapes as Concords and Moore's Early are quite certain to produce a good crop of fruit in the east half of the state at least. Some of the rough land in the eastern counties is especially suited to vineyards. The vicinity of Council Bluffs, Iowa, which is gaining a wide reputation for its grapes, presents no essential difference from thousands of acres of land on the west side of the river.

Cherries, Plums, Gooseberries, Currants, and Strawberries.—These fruits can be grown in all counties. Several of them are wild in nearly every county. There are few things grown that have ever given such large profits as are often secured from small areas of strawberries produced for the local markets, and yet few towns have a home supply. Blackberries in favorable locations are wonderfully productive and should find a place on every farm in many counties and on many farms in most counties.

Peaches are grown in a commercial way in a number of counties. Several orchards of over 100 acres are known. They can be grown profitably for home use in at least one-fourth of the state. North of the Platte river the buds are too often winter-killed for the crop to be profitable.

ANNUAL FODDER CROPS.

Sorghum.—This is quite generally grown as a fodder crop in all of the south half of the state. It is seldom grown in large fields, but a large proportion of the farmers grow a few acres. Very little is grown in the extreme southeastern counties, but it is most used in the central western counties south of the Platte. Its use here is largely due to the

difficulty experienced in growing other roughage. Sorghum is more popular in the south half of the state on account of the shortness of the season farther north. On the north the crop is limited by temperature and length of season. On the east the limiting factor is the success of better forage crops, such as alfalfa, clover, etc.

In the western counties sorghum is often planted with the lister and cultivated like corn, only it is closer together in the row. When planted this way it is cut with the corn binder. This produces coarser fodder than the thicker seeding but is much more certain in the drier sections. Farther east where there is usually more rain, this crop is sown broadcast or drilled close together with the grain drills. The method of planting is controlled by the humidity of the climate.

Sorghum has the reputation of being very hard on the ground and for this reason many farmers dislike to use it. The effect on the field is probably due to the fact that it is a vigorous feeder and a heavy producer. It also exhausts the water very completely from the soil late in the season, as well as the available plant food, so that if timely spring rains do not come, the following crop has small chance. On account of not being harvested till nearly ripe it reseeds badly. The seed retains its vitality well in the ground and it is usually several years before a field that has been planted to sorghum is entirely free from the seed. It is not a rare thing where small grain has followed sorghum to see sorghum spring up in the stubble after harvest and make a fodder crop.

When the growth of sorghum is checked by drouth, frost or any other cause the plant often becomes poisonous and is almost instantly fatal to cattle and sheep. This is especially true of the aftermath in the fall. For this reason it is necessary to take care that cattle are not allowed on the fields while the cane is still green. There is no danger whatever in the dried fodder.

In spite of these serious objections, sorghum is highly prized in many localities as the most drouth resistant and most productive of all fodders and is the main dependence for roughage. Probably 150,000 acres are grown within the state.

Kafir, one of the sorghums, is a valuable grain and fodder crop in Kansas, but requires too long a season for this state. It is used to a very limited extent in the extreme southern counties.

Milo, another grain and fodder sorghum, is now being introduced and will probably become of considerable importance in the southwestern counties.

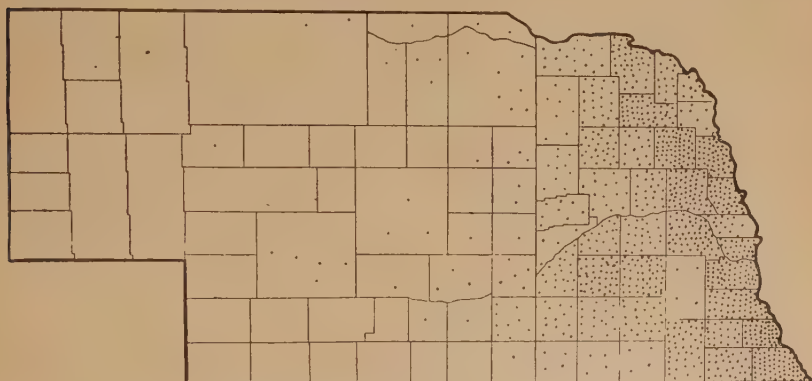
Millet.—Foxtail millets are grown in all parts of the state, usually in small fields of less than twenty acres, but the total acreage is probably a little greater than that of sorghum. German, common, Hungarian, Siberian and other varieties are used.

The German millet is the heaviest yielder in the eastern counties, but it requires a longer season and more moisture than the smaller varieties.

Siberian, which is also called Russian, and golden, is becoming very popular. This is a small variety but it is very early and sure, and produces the best quality of hay. It is also a good seed producer. Hog millet or broom corn millet is grown but little.

All varieties of millet are usually sown broadcast on freshly plowed land some time after corn planting. This is not because freshly plowed land is needed for millet, but because all other crops are then in and the millet ground has not been prepared. If the millet ground could be prepared earlier so it would have time to settle, much better results would often follow. Sometimes sowing is deferred as late as July 1, and in the southeastern counties millet occasionally follows a wheat crop the same season.

CHART No. 17.



Tame Hay other than Alfalfa . = 100 A.

PERENNIAL FORAGE.

In acreage and value the hay crop of the state (including the native hay) is second only to corn, and if we include the pasture, the total value of forage would rival if not surpass that of the king of cereals.

Tame hay and pasture crops are much more important in Nebraska than many people both in and out of the state are led to believe, but they have not received one-half the attention which they merit. It must be recognized here, as everywhere else, and the sooner the better, that the forage crop is the basis of successful and permanent agriculture.

We are safe in saying that tame hay and pasture are more important both in acreage and value than wheat. Timothy, clover and blue grass were early introduced by settlers from the states farther east. The writer is personally familiar with a number of average upland farms in Clay county which have grown clover and timothy as an important and valuable crop for thirty years. But owing to the fertility of the soil and the fair crops of hay and pasture produced by the native grasses, the need of tame grasses and legumes was not at first urgent and their spread was not rapid.

TIMOTHY AND CLOVER.

Timothy and clover are seldom sown separately and therefore will be treated together. This crop is quite generally grown in all the eastern counties, but the acreage is not large, being about 700,000 for the state. This acreage is confined almost wholly to the east third of the state, for these plants are not commonly successful west of about Clay county, although a few farmers grow them. In all parts of the state they are very successful in moist valleys.* (Chart No. 17.)

The yields of hay are commonly about one and one-half to two tons, and then a lighter second crop or a clover seed crop or pasture is secured. Some of the best managed upland meadows are producing over five tons at two cuttings in favorable seasons.†

MAMMOTH RED CLOVER.

A small amount of mammoth clover is now being used. It is sown the same as common red clover but usually without any grass. The crop is pastured until about May 1st to 15th, and then allowed to seed. The following year the ground is put back into cultivation. This makes an excellent soil renovator for a short rotation and so far very profitable seed crops, five to ten bushels per acre, have been grown.

Mammoth clover is also used sparingly in pasture and hay mixtures with good results. It is a valuable addition to mixed pastures because its ripening season is later than that of the common red.

ALSIKE CLOVER.

Alsike clover should be in all pastures on moist land. It is being used to considerable extent around Fremont in the Platte and Elkhorn valleys and some places farther southeast. Considerable is grown on the uplands around Aurora where it has given good satisfaction for twenty years or more. Some very heavy seed crops have been grown there. This clover has a distinct advantage in the readiness with which it re-seeds in meadows, fields and pastures. At Aurora one field that had grown alsike was plowed up and farmed for a number of years and then a full stand of alsike came up in the wheat and was left to occupy the ground.

KENTUCKY BLUE-GRASS AND WHITE CLOVER.

These plants are nearly always associated. They are of use only as permanent pasture. Both are shallow rooted and do not stand drouth well. A few days of hot weather in July or August stops their growth entirely. Blue-grass makes an excellent pasture in the valleys of the southeastern counties, where it grows early and late and furnishes a large amount of feed, but is not productive on most uplands. It has now run wild and takes possession of all favorable places in meadows and in pastures both native and tame. It is not often sown and while highly prized in the valleys, upland farmers usually consider it a nuisance.

* The report of only 400 acres of tame hay other than alfalfa in Lancaster county is certainly an error.

† Farmers' Bull, 325, U. S. Dept. of Agr., p. 11.

Blue-grass is one of the worst weeds in alfalfa fields and in orchards. It is often necessary to plow up alfalfa to kill blue-grass. White clover, aside from growing with blue-grass, is rapidly spreading in the Platte Valley and in the wet valleys of the Sand Hill Region. It is not looked upon with favor in the meadows, for it is ripe long before the native hay and runs out a large proportion of the native grass. It is not uncommon in these wet native meadows to see white clover standing sixteen inches high. In pastures it is often frowned upon but probably it is a benefit rather than a detriment.

BROME GRASS.

Bromus inermis was introduced some fifteen years ago and has been steadily gaining in favor, although the acreage is still small. It furnishes feed earlier in the spring than any other plant and grows later in the fall than any other forage plant except blue-grass. It grows better in mid-summer than any other grass, is more resistant to both drouth and cold, and as a pasture is preferred by all stock to any other grass. To withstand tramping it has few equals. For the best results clover or alfalfa should be mixed with it wherever either of these plants will grow. Both quantity and quality of feed will thus be much improved. In the western half of the state it is by far the best pasture grass yet introduced, and the only one that can be generally recommended, while in the eastern counties it has no equal, except perhaps blue-grass in the valleys.

Although brome grass is primarily fitted for pasture rather than for hay, it produces an excellent quality of hay and, on rich moist land, a heavy yield. On most fields, however, it does not produce well for hay after the second year unless fertilized. The stems and leaves remain green long after the seed is ripe, and there is a heavy undergrowth of leaves. This makes the stubble make good hay after the seed has been harvested. Brome grass is ready for hay fully as early as red clover and makes an excellent mixture with it. Some are using it with alfalfa also for hay and are pleased with the results. It is not so early as alfalfa and appears in both first and second crops.

Seed crops have been generally profitable. Yields of 400 to 500 pounds per acre are common and over 900 pounds have been reported. Unfortunately the seed in many parts of the state has become badly mixed with cheat grass (*Bromus secalinus* and *Bromus arvensis*). These grasses are both winter annuals. Their period of growth is the same as that of winter wheat. They ripen in June and July and then die and start from seed again in the fall. Both considerably resemble brome grass when growing, but the chaff is never purplish as on the brome grass. The seeds can scarcely be separated from the seed of brome grass and most farmers and many dealers are unable to recognize them. Several carloads of this worthless stuff have been sold for brome grass and meadow fescue in the state. In most cases the fraud has not been intentional, but the results have been to very much hinder the spread of brome grass.

MEADOW FESCUE.

Meadow fescue, also known as English blue-grass, has been used to some extent but has not become popular except in a few localities in the southern counties. It is thoroughly hardy and quite drouth-resistant, but is not the equal of brome grass in either respect. It does not spread underground, but grows in bunches. It does not form as close a sod as brome grass, neither does it produce as good hay, the stems being less leafy and much less undergrowth is produced. It has the advantage of having heavier seed of greater vitality. It is easier to sow and a stand is more certain. It has not yet proved itself a plant of any great value in the state.

ORCHARD GRASS.

Orchard grass is used to a small extent in pastures and hay mixtures with good results, but it is doubtful if it is grown alone anywhere in the state. It is giving satisfaction with both clover and alfalfa for hay. It is ready to cut with alfalfa but by the time clover is ready for hay, orchard grass is past its prime. Farmers using it with clover say they get larger yields of hay from this combination than with timothy. Orchard grass comes up with the clover and makes a much better second crop than timothy does. It has the disadvantage of growing in tussocks. It is thoroughly hardy and one of the most drouth resistant grasses.

RED TOP.

Red top is mixed more or less in nearly all timothy seed but is seldom sown intentionally. It is not productive on upland. It is a valuable grass for both hay and pasture in valleys that are too wet for timothy. It is spreading rapidly in the native meadows of the Platte and Elkhorn valleys and in the hay valleys of the sand hills. It does not make a very good hay mixture with the native grasses because it is overripe when the native grasses are ready.

NATIVE HAY.

Nearly one-half of the hay crop of the state is from native meadows. Large acreages of native grass are still found in all counties and in nearly all parts of all counties, but in some of the western sections little grass can be cut. In 1908 the native hay crop of the state was estimated at 4,066,407 tons. Upland hay is fine and very free from dust. It is made up mostly of fine leaves and contains very few stems. It is ready for cutting in August or September and so much less is damaged by rain than of tame grasses. The yield is usually three-fourths to one and one-half tons per acre. In the eastern counties this hay is composed mostly of big bluestem (*Andropogon furcatus*) but contains more or less bushy bluestem (*Chrysopogon avenaceus*), little bluestem or bunch grass (*Andropogon scoparius*), side oat grama (*Bouteloua curtipendula*) and in some places small amounts of several other grasses. On rough land there is more bunch grass and correspondingly less of the other grasses.

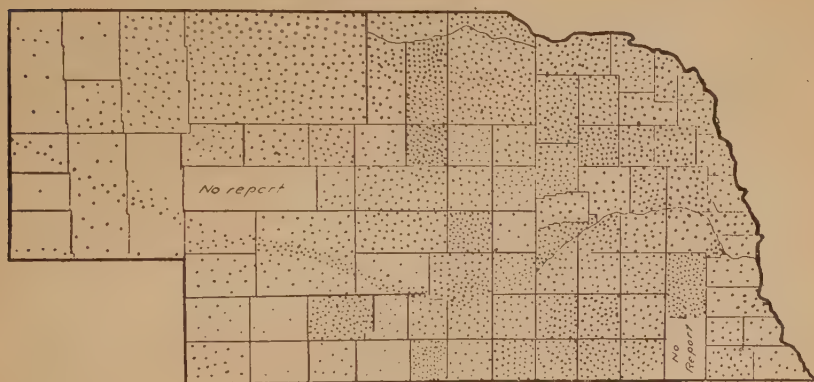
West of about the 99th meridian there is not much big bluestem except in favored locations. (Chart No. 18.)

Bordering prairie ponds and in low basins of the prairies and also on the high level prairies of the west, wheat grass forms the principal part of the hay. This is a most valuable hay especially for horses.

On the sandy prairies, such as occur in Chase and Perkins counties, hay is composed largely of sand bluestem (*Andropogon hallii*), bunch grass, and bushy bluestem. These grasses are more stemmy than the upland prairie hays and not so good. The moist valleys of the sand regions produce heavy crops of hay of a large variety of grasses, mostly bluestems, and *Panicum virgatum*.

The river valleys produce heavy crops of coarse hay, often three or four tons per acre. Frequently two crops are cut on the bottoms. This hay is composed mainly of big bluestem, bushy bluestem, *Panicum virga-*

CHART No. 18.



Wild hay . = 1,000 A.

tum and sand grass (*Calamovilfa*) in varying proportions, according to the texture of the soil and the moisture conditions. In very wet meadows sedges, mostly species of *Carex*, and slough grass (*Spartina cynosuroides*), are often dominant. The leaves of this latter grass often stand four feet in height and the stems when mature five to eight feet. This grass is used also for thatching. In many wet places red top is coming to be an important constituent. These valley hay meadows are now highly prized and are valued in many places as highly as any cultivated land. In parts of the Platte, Elkhorn and other valleys, hay is the most important crop. Thousands of cattle are wintered on this hay by turning them loose to the stacks, the owners claiming that the hay wasted by this method is not worth the labor connected with corralling the cattle and handling the feed.

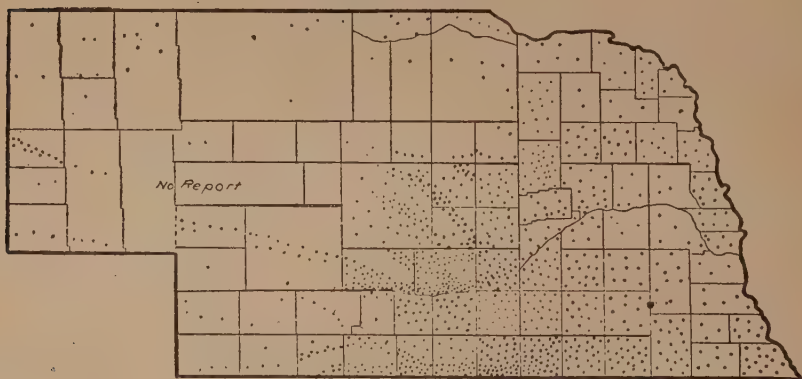
A large amount of this hay is baled and shipped to the markets of Omaha, Sioux City, Kansas City and other places where it sells at about

a dollar a ton less than native upland hay, and three dollars less than timothy.

ALFALFA.

No plant ever introduced has attracted so much attention in all parts of the state and spread so rapidly as alfalfa. No other plant except Turkey Red wheat has so changed the agriculture of the state in so short a time. Alfalfa has been a veritable gold mine to the farmers of many counties and has been one of the main factors in bringing about the prosperous condition which they now enjoy. Had this wonderful crop been known to the early settlers, the state's history would have been entirely different. Alfalfa has already revolutionized stock feeding and without doubt will soon become the most important forage of the state. (Chart No. 19.)

CHART No. 19.



Alfalfa. = 500 A.
Less than 250 A. blank.

The acreage of alfalfa is increasing by leaps and bounds. The increase in the last year was nearly 22 per cent and in the last four years 132 per cent. The crop of 1908 was 1,846,703 tons from 547,557 acres. Alfalfa in Nebraska is still in its infancy; a beginning only has been made. In the majority of counties it has scarcely passed the introductory stage. More than half of the farmers do not know how to grow it; not half realize its feed value; and not one in a hundred knows its worth as a fertilizer. It is not visionary to suggest that in the near future alfalfa may almost rival corn as the most important and valuable crop in the state, and at the same time by its improvement of the soil greatly increase all other crops.

The average yield of alfalfa hay for the state is about three tons per acre, which is usually worth \$5 to \$8 in the stack. Almost any good corn land should produce three to five tons and yields of eight tons are known. A gross return of \$40 to \$50 an acre for hay is not rare.

Four crops of hay a year are produced in the southeast counties, and the number diminishes north and west as the temperature and rainfall decrease. Three crops are usually cut in the northeast, while in the extreme western part there is no assurance of more than one crop, except in wet valleys or where irrigated.

In the southeast, cutting commences May 20 to June 5. The second crop is ready in about forty days, and the other crops require a few days longer. The last crop is cut the later part of October.

A large amount of seed is now being grown in the state, especially in the vicinity of Kearney. Some seed is grown in all parts, but in the Platte valley a specialty is made of it. Three to four bushels is a fair crop, and a few yields of sixteen bushels have been reported. Returns of over \$100 an acre from seed alone have been known, but \$20 is probably near the average. It requires about the same time to grow one seed crop as is required for two hay crops.

Alfalfa seldom seeds heavily if the ground is moist enough to produce a good hay crop. It requires comparatively dry weather to seed well. Except in dry seasons seed crops are not likely to average as valuable as hay crops east of about Hastings, but in dry seasons good crops have been known even in the river counties. When we know more about producing seed it may possibly become a very profitable crop even in the eastern part of the state.

In the western counties a few farmers are now sowing alfalfa in rows three feet apart and cultivating it much as corn is tended. So far the results secured have given experimenters high hopes of producing profitable crops of seed by this method on land that is too dry for general cultivation, but this practice is as yet only in the experimental stage.

It is not long since fall seeding began to be practiced, but it has been a success from the start, much more successful than spring seeding in all the eastern counties and in all parts when sufficient moisture has been present to give the plants a good start. Where crab grass abounds, fall seeding should always be resorted to.

Most Nebraska soils are more or less completely inoculated for alfalfa, but the more the subject is studied the more cases are found where inoculation is needed. Inoculation is absolutely necessary in but few fields, though there are many places in the state and probably in every county where inoculation would be profitable. The places most likely to need inoculation are old, badly worn fields, sandy soils, tops of hills or any places that have been badly eroded. Nearly all of the drift soils (see soil map) need inoculation. Because one farm grows alfalfa is no assurance that the next does not need inoculation; one field may need inoculation and the next not; one part of a field may be well inoculated and the other part devoid of inoculation. Such fields have been seen in many places. The bottoms of draws or any hollows where storm water runs are almost always inoculated.

Many fields are seen where the plants live but make little growth; the stems are few, short and weak; the leaves are pale, flowers are few, and little or no hay is produced. These are almost sure signs that inoculation is needed. In these fields there is generally an occasional plant that is good color and thrifty. Examination will show that these plants are inoculated. If the uninoculated plants pass the winter (which is not at all certain) they may struggle through the next season and will usually become inoculated before fall, but the use of the field has been lost. It has taken two years of time and work to get the alfalfa started. The writer has examined such fields on sandy soils northwest of Valentine, east of Ewing and north of Kenesaw, on Marshall silt loam at Lincoln, north of Falls City and other places, on drift soils near Crab Orchard, Sterling, etc., on Wabash silt loam at Red Oak, Iowa, but not in Nebraska.

Inoculation may be accomplished by scattering 300 pounds or more to the acre of soil from a good alfalfa field, or by the use of pure culture furnished free by the U. S. Department of Agriculture. It may also be accomplished by scattering manure which contains alfalfa. Spreading manure sometime before seeding, whether alfalfa hay has been fed or not, is a great help in securing a stand.

The accompanying chart shows the distribution of alfalfa over the state. Where the dots are grouped it means that the alfalfa is mostly in that locality. Webster and Buffalo counties lead, with forty-one acres each to the square mile.

The influences controlling the distribution of this crop are numerous and many of them not yet determined, because alfalfa has not yet assumed its proper position as a crop. Alfalfa came to us from the West where it was grown either under irrigation or on subirrigated land. Along with it came the opinion that alfalfa could be grown only under these conditions. A worse mistake could not have been made, nevertheless, this opinion almost limited this valuable crop to such valleys until the last few years. Nebraska farmers are now pretty well rid of this error. In Nebraska, alfalfa thrives practically anywhere where corn will thrive and in many places where corn will not. Alfalfa must have at least three feet to water, and better six, but it is not at all necessary that ground water be in reach of the roots. In the drier parts of the state, six to twelve feet of soil over ground water seems to be the best. It is not probable that alfalfa is often greatly benefited by ground water if the moisture does not rise freely to within less than fifteen feet from the surface. In other words, the depth to which roots commonly go does not seem to exceed fifteen feet.

Alfalfa thrives in all the central and eastern counties. The chart shows far the greatest acreage in the central counties, but this is no assurance that those counties are best adapted to it. As the distribution indicates, this crop has not been very successful on uplands west of about the 100th meridian. When it worked its way down the valleys

from the west it spread to the uplands as soon as the humid section was reached, the western limit of which corresponds very closely to the 100th meridian. Until alfalfa was introduced, the central counties had no satisfactory legume, but in the eastern counties clover was well established, and so the progress of alfalfa was less rapid, though none the less certain. The spread of alfalfa in the eastern part of the state has also been retarded by the fact that some difficulty has been experienced in getting it started, especially on the rolling land, the drift soils and on badly worn fields.

PASTURES.

In the better agricultural portions of the state pastures are largely confined to the more rolling lands and the wet bottoms, but on a large part of the farms there is nothing but good tillable land. The majority of permanent pastures have never been broken, and consist of native grasses, mostly bluestem. In all the farming counties from Phelps and Boyd east the dominant grass is the big bluestem (*Andropogon furcatus*) mixed in varying proportions, according to local conditions, with bunch grass or little bluestem (*Andropogon scoparius*), bushy bluestem (*Chrysopogon avenaceus*), needle grass (*Stipa*), and many other grasses and sedges. From Knox, Boone, and Fillmore counties west there is considerable wheat grass (*Agropyron occidentale*), especially on the hilly land and around the borders of the lagoons. In going westward buffalo grass (*Bulbilia dactyloides*) and grama grass (*Bouteloua oligostachya* and *hirsuta*) are first seen in pastures in about the same region as mentioned above for wheat grass. They form patches which are found mostly on the tops of hills or on the heavier, more alkaline lands bordering the lagoons. These grasses increase in importance to the westward and become dominant on the "hard" land from Keya Paha and Gosper counties west, while the bunch grass often dominates the rough and sandy land especially along the canon banks. In the sand hills there is a great mixture of grasses the most prominent of which are the sand hill bluestem, sand grass (*Calamovilfa*), *Panicum virgatum* (no common name known), and the needle grasses. In the river valleys the coarser grasses and sedges predominate, but on the alkali lands of the Platte and other streams alkali grass (*Distichlis spicata*) is the most abundant. Sedges are everywhere mixed with the grasses and in wet places are often dominant.

Over all the state native legumes form an appreciable portion of the pasture. The most important of the native legumes in the farming section are the Psoraleas (sometimes called wild alfalfa), prairie clovers (*Kuhnistera*), shoestring (*Amorpha canescens*), and ground plums (*Astragalus crassicaarpus* and other species).

Bluestems do not start in the spring till the ground is quite warm, and where they are the dominant grasses pasture is not good till May 1 to 15. In all the central and western counties the small species of sedges, such as *Carex stenophylla* and *pennsylvanica*, in the short grass

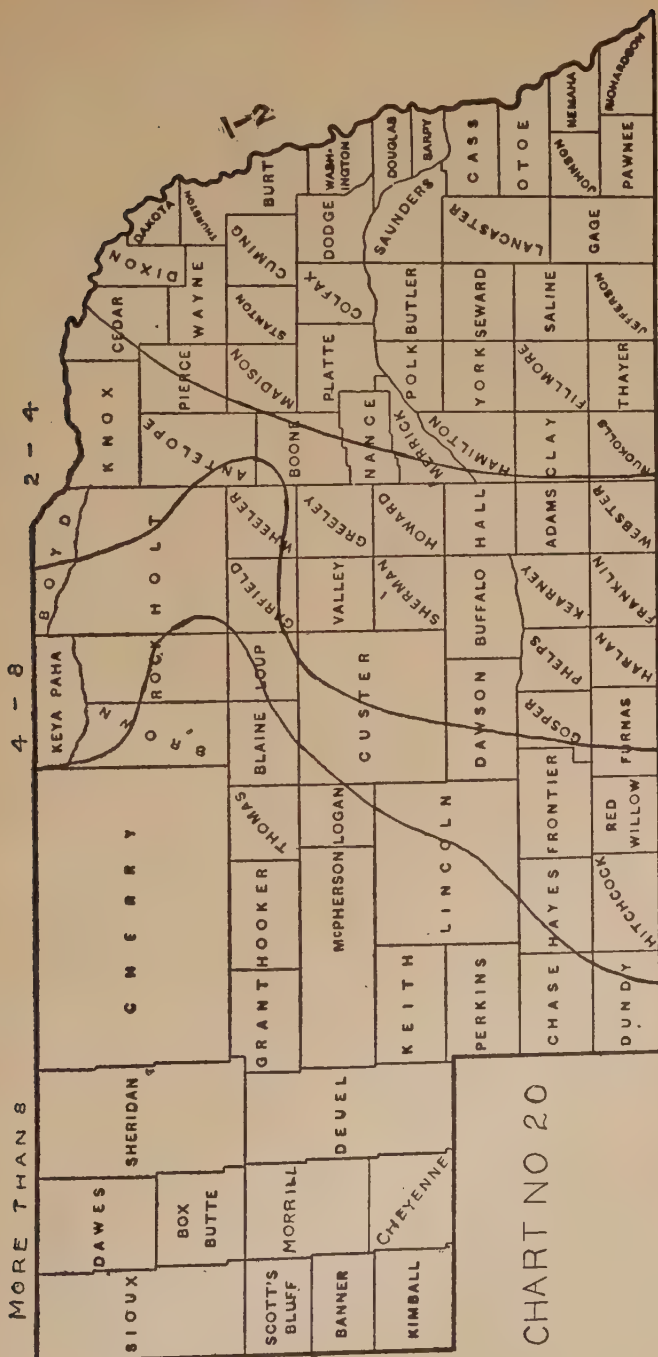
country called "nigger wool," are among the earliest plants to start and often give the prairies a green color before the main grasses are up, but they are so small and scattering as to be of little consequence as feed. Where wheat grass is plentiful pasture is available about two weeks earlier. This is very noticeable around the borders of lagoons and in many places on the rough land along the streams, especially in the northern counties. The buffalo and grama start somewhat earlier than the bluestems as does also the alkali grass. The pastures on the river bottoms generally furnish feed about seven to ten days earlier than those of the uplands. In the western and northern counties there is a larger proportion of early grasses so pasturing is not delayed so long in these parts as might be expected from the difference in climate and the difference in the advancement of crops. The pastures in the northern and northwestern counties are only about one or two weeks behind those of the southeastern counties and often not that.

In all parts pastures are at their best in June. The grasses become harder in the latter part of July and, if dry weather occurs, often become poor in August, but generally support stock till about October 1. The bluestems and sand hill grasses are killed by the first hard frost and are of little value afterwards. Where buffalo and grama grass predominate, pasturing the dead grass continues more or less all winter, but as more farming is done and more rough feed becomes available less dependence is placed upon winter pasture. These grasses, when not over pastured, furnish very good feed through the winter providing very little rain has fallen to bleach and leach them.

All the native pastures furnish good feed when in their prime and stock fattens rapidly on them, but this period is short. The sandhills furnish good summer pastures, but not much in the winter, except on the heavier soils where grama and buffalo grass grow. For winter feed the sandhill ranchmen depend largely on the hay which they cut in the valleys. The majority of stockmen want about one and one-half tons of hay per head. Where "hard" land is close at hand it is a common practice to summer the stock in the sandhills and winter it on the short grasses of the "hard" land.

In all the better farming sections of the state pastures have quite generally been over-stocked and many of them much damaged. When overstocked the legumes are practically all killed and the bluestems thinned out, while the less valuable grasses and weeds take their places. Among the worst of the weeds are the golden rods, the iron weeds, the rag weeds (*Ambrosina*), and the verbanes. These can largely be kept in check by mowing, wherever the topography will permit. Most pastures never receive any care whatever.

In all the southeastern counties blue-grass and white clover have come into native pastures and have generally improved the quality of feed and considerably lengthened the season. In the river valleys are many pastures where these grasses are in almost complete control. On such lands they make excellent pasture.



NUMBER OF ACRES REQUIRED TO PASTURE ONE COW.

Timothy and red clover are the most common tame pastures, but are generally used only a few years and then put back into cultivation. They are, as a rule, left down too long, overstocked, and given too little care. It would usually be profitable to harrow such pastures in the spring and reseed lightly with clover. The harrowing serves to scatter the manure and loosens the surface of the soil a little so that water is absorbed more quickly. Brome grass is becoming more popular as a pasture plant all over the state and, except alfalfa, is about the only thing that can be generally recommended west of the line of 26 inches average annual rainfall. Tame pastures are almost confined to the eastern third of the state.

The amount of pasturage furnished per acre is very variable, but corresponds in a general way to soil and rainfall. The accompanying chart (chart No. 20) has been made up from personal experience and from interviews with stockmen all over the state. It shows approximately the number of acres ordinarily required to pasture one grown animal through the season, which is usually four and one-half to five and one-half months, but in the buffalo grass country considerable winter pasture is generally expected. Tame pastures furnish more feed than native grass and supply it through a longer period. Valleys of course carry much more stock than uplands.

In all sections where hogs are grown, alfalfa is in common use as pasture for these animals and, next to corn, will soon be the most important hog feed as it is now the cheapest. Timothy, clover, and blue-grass are also much used for hog pasture wherever these plants thrive. On account of danger from bloat few farmers feel safe to pasture cattle or sheep on alfalfa, although good success is obtained where grass is sown with the alfalfa. The amount of feed thus produced is much greater, the quality better and the pasture season longer than can be secured in any other way.

Winter rye is used to a very limited extent for fall and spring pasture, and west of the middle of the state winter wheat is often pastured, but in the eastern part pasturing is generally thought to damage the crop too much.

STOCK.

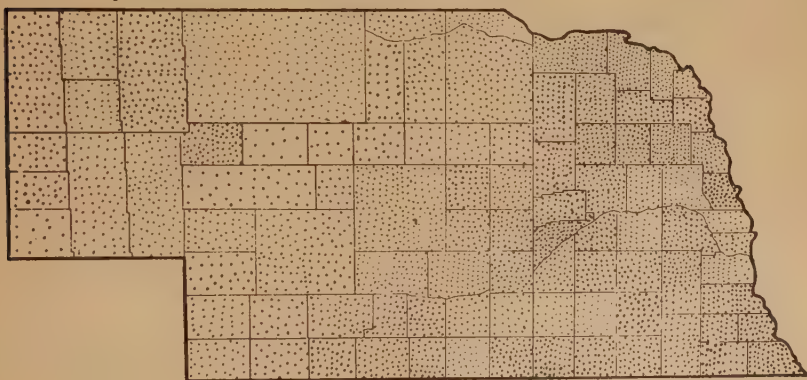
The distribution of the different kinds of stock over the state depends almost entirely upon the acreage and distribution of certain crops and pastures, and hence upon soil, topography, rainfall, etc., which control these crops, as has already been shown.

CATTLE.

No crop and no other kind of stock shows such a striking uniformity in distribution as cattle, yet close examination of chart No. 21 shows some important variation. One of the most conspicuous things brought out is that cattle are much more numerous in that portion of the state where the most corn is grown, and not in the ranch section, where little except

cattle is produced. Some of the eastern counties have more cattle to the square mile than some of the ranch counties could support if their entire area was given over to the production of cattle. A good many of the cattle in the eastern counties were not raised there, but were shipped in as feeders. On the first of April, however, the date to which these figures apply, the number of cattle in feed yards is comparatively small. Part of the large number in Merrick county is due to the fact that one of the largest feeding companies in the world has its plant there. There is a noticeably smaller number of cattle in the counties where the most winter wheat is grown. This is exactly what should be expected, for winter wheat produces no feed for cattle, while all the other crops provide roughage which has but little other use. The large number of cattle in Grant county is possibly due to cattle which range in adjoining counties, being owned by men who live in Grant county and therefore assessed there. Cattle feeding has become much more

CHART No. 21.



Cattle, April 1, 1908. = 500.

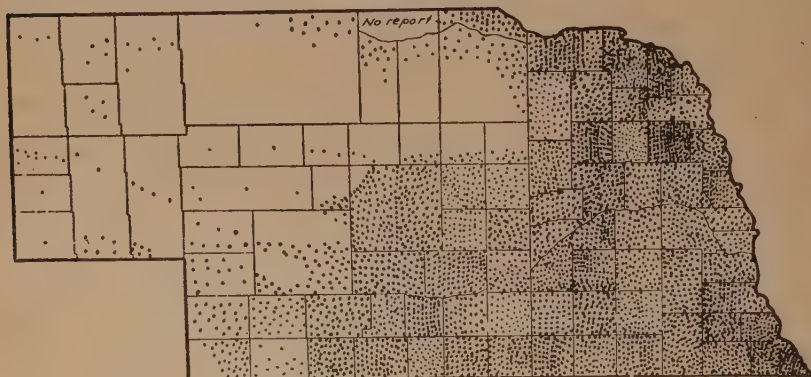
important than it formerly was in counties having a large acreage of alfalfa, while in counties where no considerable amount of alfalfa or clover is grown, cattle feeding has become unprofitable and has been abandoned. The business of cattle feeding, then, has made a very decided movement towards the south central counties in the last few years.

HOGS.

Numerous as hogs are shown to be by this chart, it must be remembered that the figures here used are taken from the assessors' returns and refer to the number of hogs over six months old on hand April 1st, which is probably less than one-half the number raised each year. A comparison of the distribution of hogs with that of corn would convince the most skeptical that the production of corn is the controlling factor

in the production of hogs. The two charts are so similar that either might almost be taken for the other. This should not be interpreted to mean that there is no substitute for corn in pork production, for this is not true, but in Nebraska corn probably constitutes over 80 per cent of all feed supplied to swine. Not only does the distribution of corn control the distribution of hogs but the amount of corn as well limits the number of hogs raised. Nebraska ranks third among the

CHART No. 22.



Hogs, April 1, 1908. = 500.

states as a corn producer and third in the number of hogs. Alfalfa is each year becoming a more important factor in hog raising and has considerable influence on the number of hogs raised, especially along the Republican river and its tributaries. (Chart No. 22.)

HORSES.

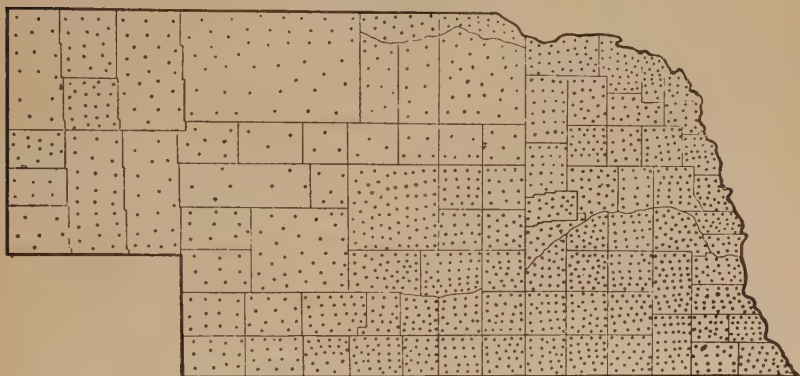
While there are some large horse ranches in the state, these animals are mostly work stock and so are distributed over the state, a small number on each farm. Many horses are annually shipped out of Nebraska, although their production for market is a specialty on but few farms and ranches. Most of the colts are raised from brood mares which are at the same time work animals. The surplus horses are nearly all produced from these mares as a secondary consideration. The number of horses is, therefore, very closely related to the number of acres under cultivation. The ratio of horses, however, to the area of farm land is by no means in all parts of the state. (Chart No. 23.)

SHEEP.

Sheep are not grown in any considerable numbers in Nebraska except on the high plains commencing in Perkins county and extending west and north around the sand hills to Cherry county. In the southeast half of the state sheep are produced only in isolated flocks of little importance. However, farmers who are raising sheep in this section

uniformly consider them very profitable. The number of flocks seems to be increasing slowly, but sheep raising is not likely to become important, at least for a long time. Sheep could be produced to advantage on many farms, but farmers are not accustomed to handling them and prefer to raise hogs and cattle. Many western sheep are fattened in this region, especially in Dawson, Buffalo, Hall, Dodge, and Richardson counties. Sheep feeding is becoming more popular, and, as the acreage of alfalfa increases and the necessity of feeding it on the land becomes more evident, this industry is likely to assume large proportions.

CHART No. 23.



Horses and mules . = 500.

DAIRYING.

In the last ten or fifteen years Nebraska has made rapid strides in dairying and has become an important butter producer. During the adverse seasons of the early 90's many farmers began selling cream from necessity and finding it profitable have continued the practice. There are few large dairies and few exclusively dairy farms except near the larger cities, but a large proportion of the farmers milk five to ten cows and sell the cream. The total number of milk cows is about 700,000 or approximately one to every two persons. These cows are, for the most part, neither dairy animals nor given dairy care. They are mostly beef breeds, and are kept to make use of the pasture lands and the coarse feed that would otherwise go to waste. The calf is on the average about as important as the cream. For these reasons the average yield of butter fat is very low, but the conditions are improving and the yield of fat is increasing perceptibly.

The sale of cream is not confined to any particular section, but of course the greatest production per square mile is in the better agricultural counties. In the western portions and in the sandhills cream cans line the depot platforms during the pasture season. In these sections

cows are generally milked while the grass is good, are allowed to go dry in the fall, and are wintered on whatever rough feed there is at hand. In this way \$2 to \$3 a month is commonly realized from each cow while in milk. Shiftless as this method may seem, it is one of the surest ways the farmer and small ranchman of the western counties has of securing a reliable income and at a time when money is often much needed.

In the past, dairying has been kept in check by the large size of the farms, the ease with which profitable grain crops could be produced, the lack of good, high-protein roughage, the lack of accessible markets, and perhaps as much as anything else by the lack of good dairymen. The development of central creameries and the establishment of receiving stations at all railroad points and many other places, has provided a ready market for cream in nearly all parts of the state and, together with the hand separator, has been a large factor in increasing the dairy business. Yet our farmers do not take readily to dairying. As a rule they do not milk unless they have to and most of them have not had to. However, the present high price of land is making it essential that greater returns per acre be realized, and dairying is one of the surest means to this end. In the better farming sections the time is past when the farmer can afford to keep a common cow for the calf she will produce. In our best agricultural counties the virgin fertility has already stood a long and severe drain, and soil conservation and improvement have become vital questions. Dairying is one of the very best ways to conserve fertility and improve crop production.

In nearly all the well settled portions of the state alfalfa is a marked success and gives large yields of the best and cheapest high-protein roughage known. Alfalfa and corn make a balanced ration for the cow. With the cheapest corn and alfalfa in the country few states have such dairy possibilities as Nebraska. With the advent of the silo for preserving the corn and with the increased acreage of alfalfa, and the rapid progress which farmers are making in dairy knowledge, the future of butter production is indeed bright. It seems certain that the dairy business is each year to become a more potent force in the economy of the commonwealth.

TIMBER, FUEL, POSTS, BUILDING MATERIAL.

In natural fuel Nebraska is extremely deficient and most of the supply is imported. Some thin veins of coal occur in the southeastern counties in the carboniferous measures and in the northeast counties in the Dakota formation. In both these areas, small mines have been operated in an irregular manner, but no mines of any considerable importance have been opened.

In the eastern counties there is considerable native timber which furnished local supplies of fuel. In part of the northwest pine timber furnishes an abundance of fuel. On many farms wood from planted

groves and orchards form a large part of the fuel. The native timber of the state probably covered about three per cent of the area.

Corn cobs are a very important item of fuel in all the corn growing section. Many farmers use no other fuel and considerable quantities are sold in towns and cities where they are found very convenient for starting fires. When a quick hot fire is wanted for a short time only, cobs answer the purpose remarkably well. They burn only a short time, however, and for that reason it is considerable trouble to keep up a steady fire with them.

POSTS.

The supply of good native post timber, although considerable, is deficient in nearly all counties. In the southeast counties osage hedges now furnish large numbers of posts. In a few places groves of honey locust and catalpa are largely drawn upon. In the northwest bull pine furnishes the posts. Large numbers of posts are imported into nearly all counties. In most of the good corn growing sections of the state both honey locust and catalpa can be profitably grown for posts. Catalpa may not be quite hardy enough for the extreme northern counties, and not sufficiently drouth-resistant to be successful in most places west of about Harlan and Phelps counties.

Catalpa trees may be expected to make posts in from ten to eighteen years. The groves that have been cut and concerning which data are available have given \$15 to \$25 a year rent for every year they occupied the land.

Every farm in the southeast half of the state should grow its own posts. The grove may be utilized also as a windbreak or it may occupy land that would otherwise be producing nothing.

BUILDING MATERIAL.

A small amount of native lumber has been sawed in the eastern counties and some from the pine timber of the northwest. Some cottonwood lumber has been cut from planted groves, but the total amount of lumber that has been sawed within the state is insignificant.

Good building stone is scarce, yet about half the counties have some usable stone. Some limestone is quarried at Weeping Water, Roca, Hubbell, Glen Rock, Johnson, Milford and other places. A few buildings have been constructed from the rusty sandstone of the Dakota measures, which crops out at Lincoln, Ashland, and other points in eastern counties. Niobrara chalk has been used to some extent along the Republican, the upper Missouri, and the Niobrara rivers. This is too soft to be of much value as building stone. In Antelope county northwest of Orchard, in the southwest part of Knox county, and in Harlan county, southwest of Alma, some excellent green quartzite building stone of tertiary age is found. At Sidney and possibly some other places, a low grade of building stone has been secured from the mortar beds.

Good brick material is found in nearly all parts of the state except the sand hills. The Niobrara chalk together with the clays and shales found with it contribute excellent cement material, and the limestones and clays of the older formations farther east are also available for this purpose.

TRANSPORTATION AND MARKETS.

Over the southeast half of the state the prevalence of gentle slopes, obviating the necessity of deep cuts, high fills and steep grades, the small number of streams to be bridged, the absence of rock, the ease with which the soil is worked, the absence in most places of all tendency to creep or slide when piled up, and the comparative firmness of the roadbed formed from it, have all worked together to cheapen and facilitate railroad construction and maintenance, and render transportation easy. This region is now well supplied with railroad facilities, there being comparatively few farms that are as much as ten miles from a shipping point.

In some of the northern counties a lack of railroad transportation still retards agricultural development, and much of the High Plains in the western counties is far from market. This is not due to the difficulties of construction but to the sparse settlement and limited amount of business. Only one railroad has as yet pierced the great sand hill belt. Here the drifting sands make maintenance difficult and the unproductive character of the soil keeps tonnage at a minimum. There are, however, many fertile tracts in this region that would be much better utilized if transportation could be obtained.

In the sand hills wagon roads are mere trails in the sand, and hauling over them is extremely laborious. The valleys could produce large quantities of potatoes and hay but it is impossible to haul such crops far over these roads. Improvement of these roads is not yet feasible in most places. Heavier materials are not at hand and the expense of constructing regular highways would be prohibitive. The commonest method of improving sand roads is to cover them with hay or coarse fodder. In some places soap weeds (*Yucca*) are used in the same way with excellent results, the roots being especially adapted to this purpose. Hay is generally cheap and plenty and the inhabitants "hay" the roads as well as the cattle.

In nearly all the agricultural section of the state good wagon roads are quite uniformly found on section lines. The same conditions which have favored railroad construction have given Nebraska probably the best wagon roads in the United States for the amount of work and expense that has been put upon them. There are seldom more than a few days at a time when good loads cannot be hauled over them. These roads, however, are capable of great improvement at small expense, and a well defined movement toward this end has already been inaugurated.

MARKETS.

The main markets for Nebraska's surplus products are Omaha, Chicago, Sioux City, St. Joseph, Kansas City and St. Louis. Hogs and poultry go mostly to Omaha, Sioux City and St. Joseph. From the west half of the state they go largely to Denver and other western markets. Cattle and sheep go to Omaha and Chicago. Horses go to Chicago and other eastern and southern points. Most of the grain that goes out finds its way to Omaha, Chicago, Kansas City and Minneapolis, but some corn goes to the feeders in Colorado. Hay is marketed largely in Omaha and Kansas City.

Grain is seldom shipped by the producer but is sold to local elevators, which are branch houses for large grain dealers in Omaha and other central points. Elevators are operated by local companies at a good many points. Nearly every railroad sidetrack has one or more elevators.

Cattle and sheep are mostly shipped by the owners, but hogs are often sold to local buyers, who ship whenever a carload is secured.

POPULATION.

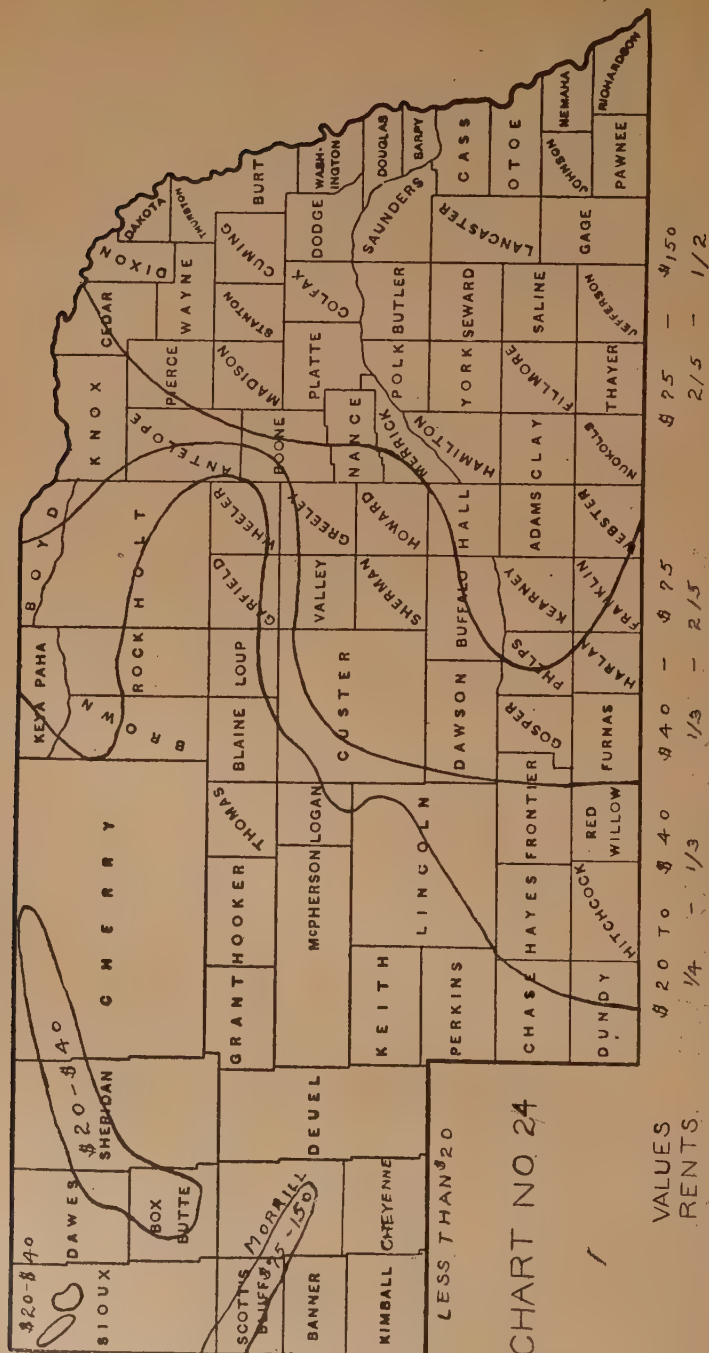
About three-fifths of the population of the state reside upon farms, and nearly all the rest are engaged in business, which is directly dependent upon agriculture. Most of the older inhabitants came from Iowa, Illinois, Pennsylvania, and the other eastern states, but there is also a large native population. In various places there are large settlements of Germans, Scandinavians and Bohemians with smaller settlements of other nationalities.

LAND TENURE, VALUES AND RETURNS.

While the majority of farms are occupied by the owners, many of whom are the original homesteaders even in the oldest counties, there is a very large proportion of the land occupied by tenants. The practices followed in leasing are as a rule very unsatisfactory to both landlord and tenant. Leases are usually for one year only, and the only thing the tenant can do is to skim the land to the limit. The most of the owners, even where longer leases are made, do not give the tenant sufficient encouragement to raise stock and sow legumes and grasses. Under this system rented farms are rapidly being depleted. Agricultural interests of Nebraska, like those of other states, are suffering from a scourge of non-resident landowners who live *off* the farm instead of *on* the farm.

Ten years ago cash rent was quite general, but now nearly all leases are for a share of the crops. Many farms in the better parts of the state return the owners \$4 to \$6 an acre in rent. It is not uncommon for alfalfa to rent for \$10 to \$15 an acre when land to be grain cropped would bring only \$3 or \$4.

An examination of the rainfall map and the soils map will readily show the reasons for the variations in land values and rents which are



PRICE PER ACRE OF GOOD, IMPROVED FARMS AND SHARE OF CROP FOR WHICH THEY RENT.

brought out in chart No. 24. No great accuracy is claimed for this chart (even if it had been accurate when made it would not likely have remained so for six months), but it will give a general idea of the conditions, and that is all that is intended.

The prices and rents here mentioned refer to good farms; pastures always rent for cash and lands unfit for cultivation, of course, sell at much lower figures. It has not seemed practical to make the lines deviate as they should to indicate conditions in the Platte valley.

FARM MANAGEMENT.

Comparatively few farms in the state are systematically managed or managed so as to even approach the returns of which they are capable. This is only the natural condition resulting from the rapid development of a new and fertile region. With the high prices of land which now prevail, many farmers, especially in the eastern counties, are realizing the necessity of greater profits per acre, and a movment for better and more intensive farming is now making rapid progress.

As in most new countries, grain farming at first prevailed, but that has been giving way to stock farming in its various phases, and for many years Nebraska has been known for her large numbers of hogs and beef cattle. The majority of land owners over most of the state aim to feed nearly all their products except wheat. Tenants are largely, though not all, grain farmers from necessity. This is because leases are generally for one year only.

On a few farms regular systems have been in use for many years and definite rotations with clover have been followed as closely as possible, with striking results. We feel safe in saying that if clover, alfalfa or pasture occupied the land one-third or one-fourth of the time, the total grain crops would be greater than they are now, and the average yields per acre from 50 to 75 per cent more. This supposition is fully warranted by the results obtained where such rotations have been in use.

Where clover succeeds, such a rotation as this is adapted to many farms:

Where Winter Wheat is Grown.

Clover and timothy hay.....	1 year.
Clover and timothy pasture.....	1 year.
Corn	1 or 2 years.
Oats	1 year.
Wheat, seeded with clover and timothy.....	1 year.

Where Winter Wheat is not Grown.

Clover and timothy hay.....	1 year.
Clover and timothy pasture.....	1 year.
Corn	2 years.
Oats, seeded with clover and timothy.....	1 year.

Besides this the alfalfa field and hog pasture (which should never be omitted) should be moved as often as possible. On many farms alfalfa will be grown but no clover. In these cases the rotation would almost

necessarily be longer. Where the stock is kept on permanent pasture the second year would simply be cut out of the rotation or the grass may be cut for hay two years. West of the clover limit there has been almost no attempt at rotation with alfalfa, although some fields have been plowed up, but rotation is needed almost as badly and the good effects are always shown. On a large proportion of the farms there should be no permanent pasture on good farm land but on many farms such pastures can profitably be maintained.

Some of the best farmers now sow clover in all small grain even though the stubble is to be plowed for winter wheat or corn. This practice is to be highly commended. It is not uncommon to get three-fourths to one ton of hay, or one-half to one bushel of seed, to the acre after the grain is off. If it is not desirable to cut hay or seed, a large amount of pasture is almost always furnished, and in every case where a stand is secured the fertility added to the soil is worth several times the cost of the seed and work. Even when the stubble is plowed as soon as possible after harvest considerable time has elapsed and the clover has made growth enough to add several bushels of grain to the acre on the next grain crop.

West of the 20-inch rainfall line, general agriculture is still in an uncertain condition, and on an unsatisfactory basis. On the heavier lands, those soils which are not so sandy as to prohibit, it now seems that the most promising system of management is about as follows: Leave a large portion of the farm, probably three-fourths, in native pasture, and keep all the dual purpose cows the pasture will carry, which would be from eight to twenty cows, along with the young cattle and colts, varying, of course, with local conditions. Always keep as large a flock of poultry as can be cared for. One of the first objects, then, on the farm land must be to raise feed for the stock. Of the farm land, one-third or one-fourth should be summer tilled each year for winter wheat and potatoes for money crops, these to be followed with corn, or some fodder crop, and the third year spring grain or summer fallow.

Assuming that the farm contains 640 acres, the above plans would give the following rotations on each field:

Three-Year Rotation.

- 1st year, summer tilled.
- 2d year, winter wheat and potatoes.
- 3d year, corn and forage.

Four-Year Rotation.

- 1st year, summer tilled.
- 2d year, winter wheat and potatoes.
- 3d year, corn and forage.
- 4th year, spring grain.

Each year the two rotations would give the following acreage of each crop on the farm:

Three-Year Rotation.

- 53 acres summer tilled.
- 53 acres winter wheat and potatoes.
- 53 acres corn and forage.

Four-Year Rotation.

- 40 acres summer tilled.
- 40 acres winter wheat.
- 40 acres corn and forage.
- 40 acres spring grain.

This system does not provide a protein feed which is necessary for best results, but no satisfactory protein crop is available. Any land that will produce alfalfa should be seeded to it, and probably with proper care this crop can be grown on nearly all lands where general farming is possible. The experiments with alfalfa in rows three or three and a half feet apart and cultivated as regularly as corn, are giving flattering results, and where it is too dry for the ordinary seeding, it seems almost certain that this method will produce valuable seed crops and at the same time some feed.

Most of the soils of the dry region are short of nitrogen and humus, and if alfalfa can be grown for a few years the land will surely produce better crops of other kinds. The writer is personally familiar with a small field of alfalfa on the plains near the west line of Nebraska which died in 1894. In the summer of 1908 the native grasses which had taken possession were more than twice as thick and tall on this patch as on the remainder of the field. In irrigated fields on the plains of Colorado yields of grain are commonly doubled where alfalfa has been grown.

This system, of course, could not be followed exactly in all the western counties, but it could easily be varied to meet the local conditions. On the sandier lands summer tillage can not be practiced and winter wheat does not stand well. Corn, sorghums, emmer and rye must be the main reliance.

In much of the rough country of the western and northwestern counties, and in the sand hills, nothing but stock production seems possible, but even here, where near enough to a station, the small stockman or "Kinkaidier" will find it almost necessary to sell cream. In the sand hills hay is usually plenty and where the settler has valleys that will grow clover, alfalfa or peas, milking should be profitable. In many of these valleys potatoes may be made an important source of income, but in some places the distance to market and the difficulties of handling make them impossible as a market crop.

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